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THE MEMORY IMAGE

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AND ITS

QUALITATIVE FIDELITY

THESIS

PRESENTED TO THE UNIVERSITY FACULTY OF CORNELL UNIVERSITY
FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

BY
I. MADISON BENTLEY.

Reprint from the AMERICAN JOURNAL OF PSYCHOLOGY
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BY

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CHAPTER I.

LITERATURE AND METHODS.

The problem which is approached in the following pages was suggested by the sections on "Central erregte Empfindungen" in Professor Kuelpe's "Grundriss der Psychologie."[1]

The author here expresses the belief that much work on memory has assumed, without sufficient cause, the presence of a memory image; too often, he thinks, the term 'memory image' has been used to cover the remnants of past experiences, whatever their relations to consciousness. As a consequence, the interpretation of results has not always been reliable. In referring to the associational school of psychology, to which this mistake is, in part, traceable, Kuelpe contends that its

[1] "Es ist aber auch erforderlich zu betonen, dass die reproducirten Empfindungen keineswegs die einzigen Hilfsmittel der Erinnerung sind" (*op. cit.*, p. 188). And concerning recognition Kuelpe says (p. 212): "Wenn man nun in den Fällen, wo eine Empfindung *a* peripherischen Ursprungs daraufhin beurtheilt werden musste, ob sie einer anderen früher erlebten *b* gleich sei oder nicht, angenommen hat, es finde dann eine Vergleichung von *a* mit dem Erinnerungsbilde von *b*, das wir β nennen wollen, statt und es hänge dann von der Treue, mit der β dem *b* entspricht, ab, mit welchem Grade von Sicherheit und Richtigkeit das Urtheil erfolge, so ist dies eine Construction, die nach unserer Erfahrung den Thatsachen keinen angemessenen Ausdruck gibt. Das Urtheil 'gleich' oder 'verschieden' wird vielmehr in der Regel ebenso unmittelbar abgegeben, wie beim unmittelbaren Wiedererkennen das Urtheil 'bekannt.'"

schema for mental contents—sensations and their weak copies, ideas—is inadequate, and even unjust to experience. Since the days of Locke, we may say, the notion of memory as a faint likeness of perception, and of 'reproduction' as a revival through imagery, has been a common one in psychology. In view of the present limitations of 'associationism,' criticism of such a notion is hardly to be avoided where rigid analysis takes its place alongside logical arrangement in psychological work.

Bearing in mind this fact, we have tried to determine the exact place of the image in the memory consciousness, and have then endeavored to discover the changes which the image undergoes in the course of time. We have set ourselves (1) to examine critically the place given the image in the memory literature, (2) to discuss the nature and function of the image and its genetic significance, and (3) to isolate the image for experimental investigation.

Although the existence and general nature of the memory image were early discussed both in and out of psychology, its more precise investigation has waited longer than most memory problems. The fact that its isolation is secured with difficulty accounts partially for this. Its neglect seems, however, to be mainly traceable to the direction from which the psychology of memory has been approached.

A history of the contributions to memory is not called for here. Several lists of the literature, more or less complete, have been made.[1] A brief sketch of the memory methods and a reference to the aspects of memory investigated will, however, be an aid to perspective and indicate at what point our own work touches the general problem.

The first problem of memory to receive wide attention was the 'reappearance' of past events through the mediation of association. As early as Aristotle, 'laws of association' were formulated which were intended to state the conditions under which ideas are brought again to the mind. Aristotle's formulation was so successful that it has passed current, with but minor modifications, until modern times. In the Empirical school of England the bipartite division of mind into 'impressions' and 'ideas,' and the attempt at analysis, brought again into prominence the concept of association. The well-known doctrine of this school, as just now indicated, asserts that ideas are stored-away sensations, and the task of their evocation is laid upon the 'laws of association,' which thus become of prime

[1] For a general and historical aperçu, see W. H. Burnham (*Amer. Jour. of Psych.*, Vol. II,) on "Memory Historically and Experimentally Considered." A recent experimental bibliography on the subject is given by F. Kennedy, *Psych. Rev.*, V, p. 477; this is, unfortunately, full of minor inaccuracies.

importance for knowledge. As every idea has been before presented as an impression (whence the famous dictum, "nihil est in intellectu, quod non prius fuerit in sensu") its reappearance through association is—so far as the arrangement of the elements is unchanged[1]—an act of memory. It is memory, then, as 'reproduction,' which the traditional English psychology emphasizes.[2]

The doctrine of association is not confined to British borders. The German Empirical psychology of the last century accepted it in a modified form. Such representative writers as Hissmann, Maass and Jacob give association a prominent place in their systems, but do not put upon it so much of the onus of mental synthesis as the developed English school does. A new scheme of reproductive motivation is advanced. There is developed the idea of a more active principle in mind. Ideas are not acted upon, but act. Leibniz' exception, *nisi ipse intellectus*, to the above-quoted dictum finds approval among German psychologists. The *Einbildungskraft* occupies an important place in their outlines. The laws of association, says Tetens (*Phil. Versuche*, pp. 108 ff.), have been over-estimated; they do not exhaust the creative activity of the mind. Reproduction as an active principle receives a more exact formulation later by Herbart and his followers. From the *Vorstellungsthätigkeit* Herbart constructs an elaborate scheme of reproduction. The tendency of the idea is, for Herbart, toward reappearance, and the success of rivals becomes a matter of mathematical calculation.

With the rise of experimental methods, memory attracts investigation in its own name. Among the incentives to recollection, association still holds a prominent place, and some of the inquiries[3] into it throw light incidentally upon various aspects of memory; but it is chiefly to direct investigation into memory itself that we must look for elucidation of memory problems.

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[1] *Cf.* Hume. It seems at first strange that Hume should make the laws of association relate to the imagination instead of to the memory. He comes to this, however, because he is thinking of a *changed* order among ideas, and only a *preserved* order belongs to the memory. The rearrangement of elements is work for the imagination. *Treatise*, bk. I, pt. I, Secs. III and IV.

[2] Spencer, one of its later representatives, thus connects association and memory: "Manifestly, associability and revivability go together; since, on the one hand, we know feelings to be associable only by the proved ability of one to revive another, and since, on the other hand, the revival of any feeling is effected only through the intermediation of some feeling or feelings with which it is associated." *Prin. of Psych.*, I, 251.

[3] Among these are the works of Galton, Trautscholdt, Cattell, Scripture, Bergström, Jastrow, Calkins, Lehmann, Höffding, Ogden.

After a glance at the literature, with reference to methods pursued, we shall have to consider how far the problems which memory presents to psychology have been disposed of and what still remains to be done. We shall endeavor to show that the science has taken up the problems from the standpoint of popular and pedagogical interest and has still before it much work, both in the analysis of the memory consciousness and in relating memory to mental processes in general. Afterward, taking up the memory image in particular, we shall outline a static and a genetic account of it which we hope may receive confirmation through special experimental investigation.

First in regard to method. The emphasis laid upon the function of 'reproduction' in the descriptive writings that we have touched upon is carried over into experiment, and we have to take account of a well-defined "method of Reproduction." Co-ordinate with this stands the "method of Recognition." This latter method was suggested by the fact that reproduction, even with the most favorable incentives, does not bring to light all that is retained of a past event. The power to recognize on the recurrence of a stimulus has become a favorite test for memory. These two methods, Reproduction and Recognition, cover practically all the experimental work on memory.

I. Under *Reproduction* we have the following contributors: Ebbinghaus,[1] who deals with the capacity of retention, measuring it by the ratio of retained to forgotten, and with various conditions of retention, *i. e.*, length of series, meaning, time interval, repetition, order, rhythm; Müller and Schumann,[2] who used E's materials with improved apparatus (Müller and Schumann extend E's results and make a special study of rhythm as a condition of retention); Jacobs,[3] who uses E's method with school children; Smith, T. L.,[4] the same method applied to muscular memory. The character and simplicity of stimulus, combination of sense modes involved, association and order, effect of age and race, and individual differences, as well as the conditions already named, have been investigated by Paneth,[5] Münsterberg,[6] Bourdon,[7] Lewy,[8] Bigham,[9] Baldwin,

[1] "Das Gedächtnis," 1885.

[2] "Exp. Beiträge z. Untersuchung d. Gedächtnisses." *Zeitsch. für Psych.*, VI, pp. 81 and 257.

[3] "Exps. on Prehension." *Mind*, XII, p. 75.

[4] "On Muscular Memory." *Amer. Jour. of Psych.*, VII, p. 453.

[5] "Versuche ü. den zeitlichen Verlauf d. Gedächtnisses." *Centralblatt für Physiol.*, IV, p. 81.

[6] *Beiträge z. exp. Psych.*, Heft IV, p. 69.

[7] "Infl. de l'age sur la mém. immed:" *Revue philos.*, XXXVIII, p. 148.

[8] "Exp. Untersuchungen ü. das Gedächtnis:" *Zeitsch. für Psych.*, VIII, p. 231.

[9] "Studies from Harvard Psych. Lab.:" *Psych. Rev.*, I, pp. 34 and 453

Shaw and Warren,[1] Smith, W. G.,[2] Barth,[3] Bolton,[4] Kirkpatrick,[5] Schneider,[6] Smith, W. G.,[7] Whitehead,[8] Hawkins,[9] Daniels,[10] Beaunis,[11] Binet and Henri,[12] Xilliez,[13] Bowditch,[14] Jastrow,[15] Courtier,[16] Vaschide,[17] Shaw,[18] Scripture,[19] Henri, V. & C.,[20] Cohn,[21] Philippe,[22] Wolfe,[23] Galton,[24] Scripture.[25]

II. The method of *Recognition* is represented by the following: Weber[26]—visual lengths and weights, Wolfe and Hirschberg[27]—tones, Lehmann[28]—brightnesses and odors,

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[1] "Memory for Square Size:" *Princeton Studies*, Sept., 1895.

[2] "The Relation of Attention to Memory:" *Mind*, N. S. IV, p. 47.

[3] "Untersuchungen ü. den Ortsinn u. ü. das Gedächtnis desselben:" Dorpat, 1894.

[4] "Growth of Memory in School Children:" *Am. Jour. of Psych.*, IV, p. 362.

[5] "An Experimental Study of Memory:" *Psych. Rev.*, I, p. 602.

[6] "Ueber das Gedächtnis f. active Bewegungen:" Dorpat, 1894.

[7] "The Place of Repetition in Memory:" *Psych. Rev.*, III, 21.

[8] "Visual and Aural Memory Processes:" *ibid.*, III, 258.

[9] "Memory Types:" *ibid.*, IV, 289.

[10] "Memory After-image and Attention:" *Am. Jour. of Psych.*, VI, 558.

[11] "Récherches sur la mémoire des sensations musculaires:" *Rev. philos.*, XXV, 569.

[12] "La simulation de la mémoire des chiffres:" *Rev. scient.*, LI, 711; and "De la mém. vis. des enfants:" *Rev. philos.*, XXXVII, 348; also *L'Année psychol.*, I, pp. 1 and 24.

[13] "La continuité dans la mém. immed.," etc.: *Année psychol.*, II, 193.

[14] "A Comparison of Sight and Touch:" Bowditch and Southard: *Jour. of Physiol.*, III, 232.

[15] "Perception of Space by Disparate Senses:" *Mind*, XI, 539; and "Memory and Association:" *Educ. Rev.*, II, 442.

[16] "Communication sur la mém. mus:" *Dritter Intern. Cong. f. Psych.*, p. 238.

[17] "Récherches exp. sur la mém. des lignes:" *Dritter Intern. Cong. f. Psych.*, p. 454: and "Sur la localisation des souvenirs:" *L'Année psychol.*, III, 199.

[18] "A Test of Mem. in School Children:" *Ped. Sem.*, IV, 61.

[19] "Researches on Mem. for Arm Mvmts:" *Yale Stud.*, V, 90.

[20] "Enquête sur les prem. souvenirs de l'enfance:" *L'Année psychol.*, III, 184.

[21] "Exp. Untersuchungen ü. das Zusammenwirken des akustisch-motorischen u. des visuellen Gedächtnisses:" *Zeitsch. für Psych.*, XV, p. 161, and *Dritter Intern. Cong.*, p. 456.

[22] "Un recensement d. images mentales:" *Rev. philos.*, XLIV, p. 508, and "Les transformations de nos images mentales:" *ibid.*, XLIII, p. 481.

[23] "Size of Familiar Objects:" *Am. Jour. of Psych.*, Jan., 1898.

[24] "Exps. on Psychometric Measurements:" *Brain*, II, p. 149.

[25] "Ueber den assoc. Verlauf der Vorstellungen:" *Phil. Stud.*, VII, p. 50.

[26] *Der Tastsinn und das Gemeingefühl*, 1851.

[27] "Untersuchungen ü. das Tongedächtnis:" H. K. Wolfe: *Phil. Stud.*, III, p. 534: v. Art. by W. v. Tschisch: *Dritter Intern. Cong. f. Psych.*, p. 106.

[28] "Ueber Wiedereerkennen:" *Phil. Stud.*, V, p. 96.

Münsterberg[1]—colors and digits, Bigham[2]—visual and auditory complexes, Baldwin, Shaw and Warren[3]—memory for square size, Schumann and v. Tschisch[4]—sounds, Loewenton[5]—space memory for the skin, Binet (*cf.* under "Reproduction")—memory for visual lengths, Bourdon[6]—letters and words. Dauriac[7]—music, Landau[8]—muscular sensations, Saborski[9]—memory for shadows.

Beside these methods, A. Binet suggests[10] the methods of *Comparison* and of *Description*. The first of these indicates a comparison of a memory with a perception and a judgment of likeness or difference; the second, as the name implies, simply a description from memory. Binet reserves the term recognition for the selection from a series of a given remembered member. J. M. Baldwin uses the method that Binet calls *Comparison*, and designates it *Identification;* Binet's *Recognition* he styles *Selection*.[11]

We have taken the words 'reproduction' and 'recognition' as convenient rubrics under which to bring various bits of work from many independent sources. These fragments represent divergent schools of method and many different points of view. The words reproduction and recognition are, however, in common usage, and, in order to an evaluation of results, they demand a critical estimate.

First concerning reproduction. It has been pointed out that the terms reproduction and recollection are extremely liable to misunderstanding.[12] The 'copy' view of memory ideas fostered

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[1] "Studies from Harvard Psych. Lab.:" *Psych. Rev.*, I, p. 84.

[2] *Ibid.*, p. 453.

[3] *Princeton Studies*, Sept., 1895.

[4] "Ueber das Gedächtnis für Komplexe regelmässig aufeinander folgender gleicher Schalleindrücke:" F. Schumann: *Zeitsch. für Psych.*, I, p. 75: W. v. Tschisch: *Dritter Intern. Cong. f. Psych.*, p. 95.

[5] "Versuche ueber das Gedächtnis im Ber. des Raumsinnes der Haut:" Dorpat, 1893.

[6] "Obs. comp. sur la reconnaissance, la discrimination et l'association:" *Rev. philos.*, XL, 153.

[7] "La mém. musicale:" *ibid.*, XXXIX, 400.

[8] Das Gedächtnis für Muskelsinn: *Wissenschaftl. Revue*, 1896.

[9] "Ueber das Gedächtnis f. Gesichtswahrn.:" Dorpat, 1894.

[10] *See Introd. à la psychologie exp.*, 1894, chapter on *Memory*, and experimental articles in *Revue philosophique*.

[11] *See Report of the Amer. Psych. Assoc.* for 1893, *Psych. Rev.*, II, 236, and *Année biolog.*, I, 607. Naturally the corresponding methods differ somewhat in detail in the hands of the two independent investigators. It is to be noted that Binet's classification falls, in point of time, between Professor Baldwin's report and later publication.

[12] *Cf.* F. H. Bradley (*Principles of Logic*, bk. II, Part II, ch. 1,), who criticises these concepts from the standpoint of logic.

O. Kuelpe, *op. cit.*, pp. 189-90.

J. Ward: *Mind*, N. S. Vol. II, p. 361. Dr. Ward says: "thus re-

the notion that reproduction is the sole vehicle of memory. Perceptions were reanimated, and brought to their new incarnation knowledge of their previous existence. Kuelpe has pointed out that so far from reproductions being merely weakened copies of sensations, they may vary in a number of ways from the latter. In fact, that recollection may be satisfied with one of a great number of marks or 'tags' by which a consciousness may refer to the past. He further makes evident that the similarity of a peripheral and a reproduced sensation is often remote, and at best the reproduced sensation is only schematic, and demands various aids, such as words, movements, organic sensations and feelings, to complete recollection (pp. 186-9). These aids may, in fact, become the real vehicle of retention, and one and the same memory stimulus may hold at its disposal a number of them. A visual stimulus, *e.g.*, may be remembered, not by a visual image alone, but by a number of auxiliary processes. There is, here, in short, a principle of vicarious functioning among mental contents. An instance may make the point clear. The writer set himself to memorize a series of digits shown successively from a drop behind a screen. Upon trying to reproduce the series immediately he found that recollection could be mediated in any of the following ways: (1) through visual images, (a) successive in time or space, or (b) grouped—hundreds, thousands, etc.,—*plus* motor memory; (2) auditory-motor images; (3) muscular images, through (a) the throat, or (b) spatial position on the table before him, indicated by pointing with the hand; or (4) the digits were retained by the imaged sound, and translated back into visual terms. Again, with a more complex series, reproduction may be aided by recognition of stimuli presented visually or auditorily. This instance will serve to show, further, the extensive field for analysis in determining, not *how much* of a simple or complex presentation can be retained for a given time under given conditions—external and internal—but *what* is the nature of the memory consciousness.[1]

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tentiveness, recognition, reminiscence, recollection are more or less lumped together as 'memory.' Ideas are described as 'faint impressions' due to central excitation; and all complexity, ascertained or inferred, is put down to 'association.' In consequence the lower animals are often credited with ideation and memory on evidence that only warrants the attribution of perception. Yet there are facts enough in human experience that show the wide difference between perception and ideation; but these facts are too liable to be confused so long as the same term 'reproduction' is applied both to the 'representative element' in perception and to the free ideas of memory and imagination."

[1] Since this chapter was written, this aspect of the subject has been again brought into prominence by Dr. Kennedy: *op. cit.*, p. 483.

Next concerning Recognition. The experimental investigation of memory through recognition dates from E. H. Weber's work with lines and weights. Weber noted that accuracy of recognition decreased with time, so that small differences became, after a time, imperceptible. Wolfe's study of tonal memory has already been referred to. He follows Ebbinghaus in seeking a ratio for amounts retained and forgotten, but uses instead of reproduction the method of recognition. The modus of recognition Wolfe assumes to be the comparison of a stimulus with a memory image. He says: "Gehen wir näher auf das Verfahren beim Vergleichen zweier durch einen Zeitraum getrennten Töne ein, so ist klar, dass ohne ein Erinnerungsbild des ersten Tons eine Vergleichung überhaupt unmöglich ist. Dieses Erinnerungsbild ist gewissermassen der Massstab an welchen der zweite oder Vergleichston gemessen wird. Bliebe das Bild in unserer Erinnerung unverändert, so wurde, wenn unsere Apperception dem Reize genau entspricht, der kleinste Unterschied immer bekannt werden." This memory image, according to Wolfe, may be already in consciousness when the second tone comes, or the second tone may call it forth (*loc. cit.*, pp. 556–58). Lehmann later uses the method to settle the respective claims of contiguity and similarity as associational connectives. Lehmann worked chiefly with gray discs. He accepts (*loc. cit.*, pp. 118–19) Wolfe's assumption of the memory image for recognition of simple objects, and concludes that, for the memory of grays, recognition consists in (1) the visual image or (2) a name. Through the mediation of this image Lehmann finds an association by contiguity sufficient for all cases of simple recognition. This result we are not here directly concerned with; but the assumption of the image upon which the result rests we shall have occasion to criticise in connection with our own investigations.

Lehmann's work was followed by a long discussion on "Wiederkennen" by Professor Hoeffding[1] in the "*Vierteljahrsschrift*" (1889–90). Like Lehmann, Hoeffding approaches the problem of recognition from the side of association. He discusses "Immediate Recognition,"[2] where no reference to the past or to attendant circumstances is traceable, and finds in place of an explicit association by which the presentation is known, a "quality of knownness" (*Bekanntheitsqualität*). The 'thing-known' consciousness refuses to be analyzed further than this: it is a case of implicate (*gebundene*) memory.

[1] Dr. Lehmann's earlier article (1889) has special reference (*l. c.* p. 97) to Hoeffding's doctrine of Association as set forth in his "Psychologie in Umrissen."

[2] An instance: a foreign word which one cannot translate but which has yet a familiar sound (*loc. cit.*, 1889, p. 425).

Whatever reproduction there is fuses with the presentation and loses its freedom.[1] The quality of knownness corresponds to increased facility of disposition[2] among nervous elements. Lehmann criticises this view, and doubts that ease of molecular movement in the cortex could be paralleled by a new conscious quality, *i. e.*, that ease of movement should have as independent a conscious concomitant as movement itself (*Phil. Stud.*, VII, pp. 180 ff.). Immediate recognition is, he says, complex and demands the presence of a memory image, or, at least, a name. Lehmann further does the impossible (according to Hoeffding), and brings immediate recognition under experimental conditions. He shows that odors may be pronounced 'known' without the arousal of any association, even a name. In these cases Lehmann assumes an association whose associated member is subliminal. This brings immediate recognition under the head of contiguity association, but only by doubtful reference to 'unconscious reproduction.' Lehmann's further point, that the feeling tone of odors varies independently of the 'knownness' or 'unknownness' of the stimulus, and hence cannot mediate recognition, is overruled if the feeling of recognition is assumed to be unique. This assumption has lately been supported by Professor Washburn (*Phil. Rev.*, VI,

[1] *Cf.* Spencer's scheme of Association. He says (*Princ. of Psych.*, Vol. I, p. 256): ". . . . The primary and essential association is between each feeling and the class, order, genus, species and variety of preceding feelings like itself. This association . . . . constitutes the very recognition of each feeling." A. Bain takes a similar position (*Senses and Intellect;* third ed., p. 458). Dr. Ward, criticising this view, says: "The characteristic peculiarity of this process of assimilation or immediate cognition is that there are not two presentations, A and B, directly given as a part of the fact to be explained. Two presentations have simply been assumed in order to bring assimilation within the range of the more comprehensible processes of association." (*Loc. cit.*, p. 353.)

Ward prefers to call the process of recognition assimilation, and emphasizes its subjective, apperceptive side. "The mere sense of familiarity or facility is then but a subjective state partly active, partly emotional." (p. 532.)

There has been some confusion, in the literature, of 'cognition,' 'association,' and 'recognition.' On this see A. Allin, *Amer. Jour. of Psych.*, VII, pp. 237 ff., February, 1896; also M. W. Calkins, *Psych. Rev.*, *Monograph Supplement*, February, 1896.

[2] Ward criticises Hoeffding for wavering between nascent ideas and a feeling caused by ease through repetition, as explanations of immediate recognition. The criticism seems to us perfectly just. M. Offner (*Philos. Monatshefte*, 1892, pp. 406 ff.) argues that the ease in recognition must be translated into some other terms in order for the presentation to be known as a repetition. Hence it is not ultimate, *i. e.*, it is not 'immediate recognition.' *Cf.* Külpe, *op. cit.*, p. 179.

For the physiology of Hoeffding's 'ease' *cf.* Van Biervliet; *La Mémoire*, 1893.

p. 267), who makes the feeling of recognition a "peculiar property of centrally excited sensations,"[1] and suggests that it may be paralleled by excitation of connective brain tracts which mediate such sensations. These connective tracts thus perform a function for feeling similar to the ideational function which Spencer gave them as substrate for ideas of relation (*Princ. of Psych.*, I, p. 270). Wundt also speaks of a 'feeling of recognition' (*Phil. Stud.*, VIII, pp. 351–5), but demands ideas in the background. Professor Baldwin's explanation (*Mental Development*, 1895, pp. 313 ff.) differs from Hoeffding's only in placing the 'ease' of recognition in motor phenomena connected with the attention. An attempt at analysis of what Hoeffding calls the quality of knownness has been made by Kuelpe. Kuelpe thinks that it consists "(1) in the especial effectiveness for central excitation of familiar impressions or memory images, and (2) in the characteristic mood which they ordinarily induce and which embraces both pleasurable (or at least comfortable) affective states[2] and the corresponding organic sensations" (*loc. cit.*, p. 178).

Later investigations of recognition (see list above) add little to the method. The process of recognition is left in an unsettled state, though its quantitative expression of retention has been much dwelt upon. The discussions at least raise a doubt whether reproduction, in its real sense, and recognition do not stand for quite different processes. This point awaits further investigation.

The method of *Comparison* (Binet) is easily brought under Recognition in the broad sense in which we have used the latter word. In the meaning that Binet gives the terms the chief difference seems to consist in the number of decisions made by the observer. In his Recognition (Baldwin's Selection), unlikenesses are observed until the desired member of the series is found, and then a judgment of likeness is passed: in his Comparison (Baldwin's Identification), one judgment of likeness or difference suffices, *i. e.*, Recognition is reduced to its lowest terms as regards its object.

Description, similarly, for present purposes of classification, may be subsumed under Reproduction: it is verbal-motor reproduction. It seems not to have been much used as a memory method. It has two disadvantages: (1) its report must always be inadequate and (2) involve other organs than the

[1] *Cf.* B. Bourdon (*Rev. philos.*, XXXVI, 630): "reconnaissance est une sorte de *sentiment*."

[2] The effectiveness of mood in memory has recently been remarked by R. MacDougal (*Psych. Rev.*, V, 463), who contends that music at times creates a mood which, once instituted, attracts appropriate [illegible]

ones receiving a memory stimulus. On the other hand it has a decided advantage where complex stimuli are used and direct 'reproduction' is impossible. As Binet suggests, it might be used to test the accuracy of memory for past events which were not at the time of their occurrence translated into verbal terms. Description is the memory method of every-day life, but has not yet commended itself to the experimental psychologist. A phase of 'reproduction' quite analogous to the method of description, and identical with it in principle, is the representation of a visual stimulus through the hand, *i. e.*, a form drawn, or a color painted or mixed in solution, or again, a visual length reproduced on paper.[1] The constant errors in all these cases demand special attention.[2]

We shall attempt to show (Chap. III) that a complete catalogue of methods must take into account the presence or absence of the memory image, a condition which the current methods imply but do not usually fulfill.

Reference to the more important experimental contributions to memory reveals a general tendency to emphasize memory as power of retention. This power has, of course, no direct organic expression; hence it can only be inferred from reproduced or recognized contents. Retention becomes a capacity measured in one of these two ways. The important work of Ebbinghaus, which has served as model for numerous later inquiries, takes up the problem, *How much is retained under given conditions?* He finds, *e. g.*, that, other things being equal, retention is a function of time elapsed. There is little to indicate what the memory consists in—what a cross section of memory contents would show; whether the presentation is carried over, modified or unmodified, by memory, or replaced

[1] Work similar to this is suggested by J. McK. Cattell (*Science*, N. S. II, 761) and repeated by F. E. Bolton (*Psych. Rev.*, III, 286) and Franz and Houston (*Psych. Rev.*, III, 531). Dates, events, distances, weights, forms, etc., were recollected by their pupils and put down on paper. The records show a confusion of observation and retention capacities and have little value as memory results. Thus, *e. g.*, the members of a class were asked to indicate the time taken to walk some familiar distance. The result is not primarily a memory result at all, since it does not show what the several individuals knew and remembered, but only an estimate (from various data) of something which they did not know directly. This fact, of course, does not bias their anthropometrical application, which Cattell indicates.

[2] A case in point is the work of H. K. Wolfe, on "The Memory for size of familiar objects" (*Psych. Rev.*, January, 1898). Wolfe found that some familiar objects, as bank notes, were under estimated when drawn in outline on paper. Plainly this fact does not necessarily report the visual image of the note, since reproduction might easily be biased by the introduction of alien senses, *i. e.*, pressure, muscular exertion, etc. In fact, by different methods, Baldwin (*loc. cit.*) finds that square size is *over estimated* in memory.

by wholly different contents subserving retention. Wolfe, indeed, criticised Ebbinghaus's method as involving too complex conditions; but his own results are the same in kind, *i. e.*, they register the capacity for retention—in this case for tones. Recognition, he asserts, is mediated by a comparison of a tone heard with the image of one remembered, as we have seen. The possibility of other operations in the memory, he does not consider. Still, the material used—tones with small pitch-differences—is probably the simplest available. It cannot be said that Lehmann's work deals primarily with memory. He uses Wolfe's method to ascertain the form of associative connection in recognition.

Beside the capacity for retention of nonsense syllables (Ebbinghaus, Müller and Schumann, and Jacobs), and of tones (Wolfe, Hirschberg and Courtier), we have similar results for retention of letters (Cohn and Smith, W. G.), time interval (Paneth), visual length (Weber, Binet and Henri, Vaschide and Münsterberg), visual size (Baldwin and Wolfe), digits (Bolton, Münsterberg, and Binet and Henri), extent and direction of movement (Münsterberg, Schneider, Smith, T. L., Beaunis and Bowditch), lifted weights (Weber, Wolfe, Landau and Müller and Schumann), tactual space perceptions (Barth and Loewenton), colors and brightnesses (Lehmann and Münsterberg), noises (Schumann), letters and words (Bourdon), and odors (Lehmann).

We intimated above (p. 4) that the course of the work pursued in memory is largely explicable if we take account of popular and traditional conceptions of memory which psychology seeks to make coherent and definite. The case has many analogues in the history of science and philosophy; learning finds its problems ready-made in the medium of common thought. In the instance before us, memory has an obvious importance for mankind. The power to retain and revive experiences is continually put to the test. It is not surprising, therefore, that we find this aspect dwelt upon in popular reflections upon the human mind,[1] and the rise of experimental methods naturally lays emphasis upon the *quantitative* statement of memory's capacity.

Again, the value of much of the work of this kind for practice is apparent. Education gains by any careful inquiry into the human mind. To see science pressed by practice for contributions to utilitarian ends is not unusual. The natural sciences and their corresponding arts afford many

[1] One seems to see a direct connection between the loose ends which experience brings to reflection upon mental phenomena and the generation of a 'faculty psychology' which conceives the mind as a bundle of powers, or capacities for practical activities.

instances of this; medicine, *e. g.*, gathers tribute from physiological estimates of bodily function. A similar levy is laid upon psychology by pedagogy. The *practical* bearings of the facts of habit, attention, memory and apperception explain the drift of much material collected upon these aspects of mind. Reference to systematic works on pedagogics shows, on the one hand, the assumed importance of these rubrics for the art of teaching, and, on the other, their dependence upon psychology.

It is, nevertheless, clear that the quantitative aspects of memory and attention do not exhaust them for psychology. Consider memory. So far as we have looked into the literature, analysis has been seen to play a minor part. The contributions to the subject have measured the volume of the stream and the pressure at given points, to a neglect of the contents. Conventional terms have, in many cases, been substituted for analytic work. One step in advance has indeed been made. A general 'faculty' of memory has been resolved into a plurality of memories. Mental pathology, nerve physiology, and psychological experiment have brought about this advance. Some attempt has also been made to ascertain the dependencies of one sense-memory upon another; *e. g.*, Cohn attempts to control the acoustic-motor and visual memories and to show the effect of their combination and isolation. Whitehead and Smith, T. L., have made similar attempts, and Binet compares two extraordinary memories, one a marked visual, and the other an auditory type. Galton goes still further and makes independent exploration into the capacity for visual imagery among various classes of individuals (*Inquiries into Human Faculty*, pp. 83 ff.).

The work which we propose to outline in the following chapters is directed primarily to the analytic side of memory;[1] to

[1] It remains to be said that Dr. Kennedy (*op. cit.*) has already pointed out the lack of analytic work in memory investigations and has urged its importance. There are, however, two or three places in his treatment of memory problems in which we disagree with this writer. These seem important enough to mention. They are the following: (a) 'Recognition,' he says, is distinguished from 'reproduction' only by the "expression on the part of the reagent of the state of the condition of the memory:" *i. e.*, by the memorial report. Plainly, there is a failure here to distinguish between 'direct' and 'indirect' sensible discrimination; between the experience and the report of the experience. When the writer makes every experiment on memory fall into two parts: A, the stimulus, the thing to be remembered, and B, the report (478), he leaves out just the important factor, namely, the psychological experience. This he does bring in later as the image, which he makes essential to any memory (485), but he does not recognize its importance for method. In our view (1) method properly turns on the *psychological* factor, and here (2) we may, or we may not, have a memory image, as we have before indicated. (b) Our experience con-

the contents of the memory consciousness, and more particularly to the part played by the memorial image. The following chapter will consider the image in its genetic and functional connections as a preface to the experimental inquiries into its nature and fidelity.

CHAPTER II.

The Genesis and Function of the Memory Image.

The term 'Image' has a wide significance in Psychology. Its original close connection with vision—the retinal picture or image—is apparent. The use of 'image' as 'retinal picture' is moreover not wholly technical; the word has a like significance in every-day life. The image is the copy of the *real* in ordinary speech; the eye, like a mirror, reflects, reduplicates 'the world.' It is then but a step to the image as a picture of the memory. "The face is graven on my memory," we say, as if it were an intaglio cut in stone.[1]

The language of psychology has extended the term memory image from its connection with vision to various mental contents which represent a definite past event, without regard to the sense affiliations which the contents may reveal. Psychology has also added to the nomenclature of imagery the terms 'positive after-image,' 'negative after-image,' 'memory after-image,' phantoms of sensory memory, hallucinations and illusions. Fechner was the first to complete the list and to give a

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tradicts Dr. Kennedy's distinction of (1) "immediate" (simple) and (2) "mediate" (complex) memory materials; *i. e.*, we are said to remember a thing (1) directly, "as it appeared in reality," or (2) "by means of concepts." We do not find that a thing is remembered "mediately," "conceptually," by "classification," when or because it is complex: one's memory of a man or a house *may* be direct, may be simply a visual image or, on the other hand, one's memory of a simple visual quality, *e. g.*, a red, may be indirect, mediate, *i. e.*, through a word; nor should we call Ebbinghaus's material necessarily "conceptual" (as the writer does) but simply complex and variable: it involves several memories, but not necessarily classifications. An eye-ear-memory *may* be direct and immediate. We agree that these pioneer experiments give us functional rather than structural, existential, analytic results. (c) We take issue with the statement that the incentives to memorial transformations are always unconscious (490). In Chapter III, we bring a case in which the conscious filling of the memory interval affects the fidelity of the memory.

[1] There is an evident influence of this trope on the creation of the 'idea' in Humian psychology. *Apropos* of this, A. Frazer (*Amer. Jour. of Psych.*, IV, pp. 230, ff.) has called attention to the important influence of visualization on the construction of the psychologies of Hobbes, Locke, Berkeley and Hume. He concludes that 'idea' for these men connoted the visual image of the memory.

full description of these phenomena. They differ mainly, on the physiological side, in a more or less remote connection with excitation of the sense organs. Positive and negative after-images receive due attention in connection with theories of vision; abnormalities of the imaging capacity, as phantoms, hallucinations and illusions come under the direct care of the mental pathologist;[1] the memory after-image seems to be a special case under memory images proper, whose scanty literature calls for new investigations.

As the psychology of sensation and perception comes before the treatment of the more involved data of mind, so memory must be reduced to its lowest terms before its contents will easily submit to analysis. There is consolation here, as elsewhere, in working among the more elementary processes: the beginning may be more than a beginning, for the simple is sure to betray something of the nature of the complex, and thus the full analysis of the latter the more quickly follows. Psychology has often been asked to justify herself against the charge that she analyzes out 'mind' and only juggles with the inert remnants; but she is firm in the belief that careful analysis is the one initial procedure with complex processes whose outcome the history of science guarantees. The problem of the fidelity of the image is peculiarly dependent upon simple contents which are unequivocally related to definite peripheral excitations, since the character of the image is ascertained by its comparison with an external stimulus. In other words, we face a psychological problem on the assumption of a definite relation between stimulus and sensation. The uniqueness of the problem consists in the fact that a peripherally aroused sensation is here compared with one centrally aroused, instead of with another peripheral sensation.[2]

Before proceeding with an account of special investigation two preliminary questions confront us: (1) the relation of the memory image to perception, and (2) the function of the image in the life of the organism.

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[1] As Burnham points out (*Amer. Jour. of Psych.*, II, p. 456) there is close connection between the normal phenomena of memory and its pathological manifestations. It is not essential for our purpose, however, to discuss the pathological side of memory. The literature, though recent, is already bulky. But a theory of the image and its physiological substrate has to look very carefully not only into the direct disturbances of memory but also into the interferences in perception caused by various forms of aphasia.

[2] The terms "peripherally" and "centrally aroused sensations" are, of course, not to be confounded with Spencer's classification of sensations and emotions into "peripherally" and "centrally initiated feelings."

(1) It is quite evident that all developed[1] perception involves the past experience of the individual.[2] It is equally evident that not all perception involves a memory image. Where the image appears we have to determine.

The attempt has been made to base perception upon association aroused by external stimulation. Spencer, *e. g.*, includes under association the assimilation of past experiences to a new one of a similar kind (*l. c.*). Now it may well be that every central excitation leaves its record (in what way we do not know) in the brain, at least for a time, but this is quite different from the assumption that past events necessarily appear in consciousness, according to associational or other laws, when a similar present event occurs. Exploration of the perceptive consciousness, at least, fails to return evidence of such appearances, except under certain rather exceptional conditions. It is conceded, of course, that a perception is often a direct incentive to the arousal of memory images, but it is not clear that the perception is conditioned upon such arousal. Even recognition, which is psychologically a degree more complex than mere perception (or cognition, as it is often termed in distinction from recognition), need not involve 'reproduction,' as we have tried to show. Whether direct recognition be referred to a "quality of knownness" (Hoeffding), or to a unique feeling of recognition (Bourdon and Washburn), or to a "fringe of tendency" (James, *Psych.* II, 674), or is further analyzed into a mood, *plus* the power to excite central areas[3]

[1] Memory as a function of organic matter would figure in all instinctive and habituated response to stimulation; but we are not here concerned with this conception of memory (*cf.* Hering: "Memory as a Function of Organic Matter").

[2] Wundt says (*H. & A. Psych.*, p. 347, trans.): "Memory of some kind is involved in the cognition of an impression; memory of a definite kind in its recognition."

[3] The meaning of Kuelpe's phrase "in der besonderen central erregenden Wirksamkeit" (p. 178) is a little doubtful. It can hardly mean that an object is known because of a potentiality to attract excitation at the center (*cf.* Hoeffding's *Vorstellungs-potentialität*). The 'knownness' must be paralleled by some aspect of central excitation itself and not by a mere capacity. Perhaps the 'effectiveness' consists in an incipient re-excitation of certain centers. This is supported by the sentence a little further on (p. 178): "zu specielleren Urtheilen pflegt es bei diesem unmittelbaren Wiedererkennen nicht zu kommen, gewöhnlich wird bloss der Name 'bekannt' sofort reproducirt." We need not, however, assume, as Dr. Washburn seems to demand (*l. c.*, p. 270), that, the word 'known' is mediately reproduced through precedent conscious processes. It is conceivably sufficient that the repeated stimulus may itself immediately call up the word. It is not, however, our experience that *any* verbal impulse necessarily attaches to the 'familiar.' It seems to be often replaced by a general psychophysical attitude towards the known object. It is difficult to make this more explicit, but very probably the attitude is to be explained

(Kuelpe), the necessity of reproduction may be avoided. If reproduction is still urged in the form of 'dark images' (Wundt, Hoeffding and Lehmann), which introspection does not reveal, the *onus probandi* seems to fall on those who press the hypothesis of effective subconscious imagery.

No stimulus to sensation comes as entirely new to the organism: in other words, every *conscious* excitation, at least, awakens some reaction. From the side of consciousness, this means that everything goes together somehow in the individual's experience, *i. e.*, has a meaning; from the side of general nervous functioning we may say that every excitation that reaches the cortical centers disturbs a definite cortical area. The extent and nature of the excitation condition the resulting consciousness. The meaning involved we call cognition, recognition, train of thought, logical thought, etc. Now the place where the memory image appears, and the part it plays in contributing to meaning, are important. If we were to give a progressive series of the simpler types of meaning it would run something like this:[1]

I. Cognition or simple perception. No associations necessary. A minimum of meaning. (Wundt calls this assimilation, or simultaneous association, *i. e.*, fusion of sense impression and memory image, *plus* feeling of cognition; Spencer, association.) No image discoverable through introspection.

II. Recognition. A. Direct. i. Without interest. Taken-for-granted stage. Well-worn environment. A general feeling of comfort and security. Approaches *I.* No image.

ii. With interest (active or passive attention): object stands out from environment. Only association is verbal 'known,' which may be replaced by motor impulses. (Hoeffding finds 'quality of knownness;' Lehmann and Wundt, 'dark images;' Kuelpe, a mood *plus* tendency to central excitation; Ward, an assimilation process; Washburn, an unanalyzable feeling of recognition.) No image.

iii. Enforced (extrinsic) interest (active attention), *e. g.*, simple recognition under experimental conditions. Judgments 'like' and 'different' follow. Image not necessary.

iiii. Direct Recall: Memory in the narrow sense (Bradley, v. infra); 'pure' memory (Bergson, v. infra). A definite past, with subordination or exclusion of the present. Image essential.

B. Mediate. i. Through auxiliary ideas or other motives to recognition; *e. g.*, person recognized from description. May be image.

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by definite impulses to movement. Since familiarity differs in degree rather than in kind, the same motor reaction would be interpreted as object-known for a great variety of stimuli.

[1] This, of course, is not, in any sense, a genetic scheme.

ii. Conscious comparison of object and image. Image necessary.

This classification, though tentative, may serve to indicate the direction of increasing complexity of meaning which the simpler processes—those closely allied to sensory stimulation—exhibit. No hard and fast lines can be drawn between the various rubrics, and this indicates the continuity of the series.

The classification suggested will be further substantiated if we find that it agrees with the rationale of the development of the memory image. This brings us to our second point, and we have to ask what is the genetic significance of the image.

(2) If we take the biological point of view, it seems altogether probable that the memory image was a comparatively late acquirement for the organism. A command of consciousness through active attention, that should abstract from the pressure of the immediate environment and hold an isolated sensation-complex, aroused by central excitation, is the prerequisite of the image. A highly complex nervous apparatus seems necessarily involved.[1] The primary use of the image, we surmise, was to carry the organism beyond the limits of the immediate environment and to assist it in foreseeing and providing for the 'future.' Its function seems, then, to have been a prophetic one; it was a means to what we may term *remote adaptation*. The capacity to image is a prerequisite for a future. The extension of temporal and spatial relations has been immensely facilitated by excursions of consciousness beyond direct perception. In fact, the past and the possible (the not-yet), essentials for a developed time consciousness,[2] must have waited upon the power to abstract from the present. The mere presence of an image does not, of course, explain the complete elaboration of times. But when once the capacity for independent imagery has been acquired, the stress of existence will inform the image with significance.

The significance will, undoubtedly, be vague for a time. The image will mean a situation which does not belong to the one immediately presented; its temporal situation will still be

[1] The contention that some of the higher animals, *e.g.*, dogs, dream, does not seem improbable if we consider dreaming as one of the earliest—perhaps the earliest—appearance of the image. Oblivion to external stimulus might well be the prime condition for full consciousness of events not connected with perception. The pressure of the senses during waking life makes a practical demand on the attention which leaves little chance for central excitation to hold consciousness in its full right. It is indeed only at a comparatively adult stage that man performs the feat of total abstraction from the present.

[2] We do not, of course, mean mere temporal succession, which exists long before the differentiation of times past, present and future. *Cf.* Stern: Die psychische Präzenzzeit. *Zeitsch. für Psych.*, XIII, 325.

unfixed. Later, its extreme importance will attract the attention, and thus it will be reacted upon. As an element in action, it will become more and more teleological; it will become the headlight of consciousness, pointing before to an experience which is to follow, and which must be provided against. Thus two things are important in determining its setting: (1) it must be joined with the motor mechanism, and (2) it must be found to be a term x in a series starting from a present a; *i. e.*, it must be brought, in a twofold way, into connection with immediate perception.

The past, being less important than the future, must have been known, as such, later. Still, the future having been once created through the pressure for survival, the past would soon follow. A different connection with the present, would change the tense. Strangely enough, the past seems to have been more the fruit of leisure and idleness than the future. There is an instructive analogy among the earlier forms of civilization, where the historian is a much less important personage than the prophet, the soothsayer and the seer. Even for us the function of history is apt to be rather oracular than reminiscent.

Thus the general function of the image is analogous to binocular vision and binaural audition. The image does for temporal orientation what two eyes and two ears do for space perception. It adds perspective in time; these provide perspective in space. The former gives the distant in time from 'now;' the latter the distant in space from 'here.'

The necessities of life, however, must have demanded a suitable reaction upon environment long before images appeared. Wundt contends that the definite reaction upon food stimulus seen in the lower forms of life is to be explained "on the assumption that inherited organization determines the correlation of pleasurably toned sensations with certain sense-impressions, and that these sensations are connected with the movements subserving nutrition" (*H. & A. Psych.*, p. 348, trans.). This consciousness he calls cognition. Even recognition, which Wundt connects with "memory of a definite kind" (*op. cit.*, p. 347) and ascribes to the higher animals, might precede the power for independent images. This is borne out by the well-known fact that recognition is often possible when 'reproduction' fails. This accounts for our confidence when we say, *e. g.*, "I don't recall his face, but I should know him if I saw him." Similarly, in learning a language, many words absolutely refuse to be recalled which are recognized on sight. It is a doubtful explanation to say that the sight of the word is only a better incentive to its recall than is otherwise obtainable. How can it be an incentive until the word is first known and

its meaning adumbrated? And after the word is known, what is the need of an incentive? Again, Galton says (*Inquiries*, p. 97): "the visualizing and the identifying (recognitive) powers are by no means necessarily combined." And Ward points out (Art. "Assimilation and Association." *Mind*, N. S. II and III) that assimilation is prior to association and quite distinct from it. He argues that true memory is not involved in the former process, but arises only through association, which presupposes the connection of A and B by apperception in order to a recovery of the memory *b* through the recurrence of A. He holds that such apperceptive connection could appear only at a late stage of development. F. H. Bradley, in a recent article on Memory and Inference (*Mind*, Apl., 1899, pp. 145 ff.), remarks that "to know the past or future as such is a hard and late achievement of the mind, for it implies an enormous degradation of the present. . . . . Past and future do not and cannot exist for us until reality appears as a series in which the present has sunk and has become but one member among others." He continues by affirming that the emergence of a past and a future marks the line between the animal and the human mind.[1] The animal has "no world sundered from the world of its immediate practical interest, and to take an immediate practical interest in the past as past is surely not possible." (1) Like most attempts at fixing landmarks in genetic psychology, Mr. Bradley's is balked by too great preciseness. Lacking very definite data, psychology will hardly be satisfied at this day by a proposal to set off sharply the human from the animal mind by any broad functional activity, such as 'reason' or 'memory.' In this case it seems better to leave—until the *experimentum crucis* is made—the advent of the image more indeterminate, but to insist on its recentness. (2) As to the impossibility of an animal's "practical interest in the past," we repeat our suggestion that it is adaptation which attracts the first practical interest in the image. That the image should stand out *at all* from the 'present,' may, in part, be laid to the incompatibility of the 'perception' and the 'image,' as Mr. Bradley suggests.[2] But it is possible, also, that the image, considered apart from its proper function, as simply conscious event, may be quite different in quality from those sense impressions which mean for the animal immediate or present

[1] This line of demarcation was also suggested in 1886 by Ch. Richet; *Rev. philos.*, XXI, 587.

[2] Mr. Bradley's account of the genesis of memory seems to us to fail because it leaves out of regard feeling and volition. It is pre-eminently true of the simple mind that it learns by doing. No abstract consideration of associational series of ideas will account adequately for the development and extension of consciousness.

'reality.' May not the close relation between peripherally and centrally excited sensations be explained by similarity of function? A book before me now and remembered from yesterday is one book, whether perceived or imaged. The perception and the image mean for me one and the same object. But if we grant a qualitative difference[1] between them, we have an argument to add to Mr. Bradley's argument from incompatibility.

There is to be noted in this connection a recent monograph by E. L. Thorndike, on "Animal Intelligence." On the basis of experiments with cats, dogs and chicks, the author concludes that these animals are devoid of 'reason,' inference, and comparison, but are capable of forming associations; not associations of ideas, necessarily, but associations of sense impressions with impulses to activity. He finds no proof of the existence of 'free ideas,' 'representations,' or 'memory images,' and raises a doubt whether these appear at this level of animal intelligence. If representations are already present, he maintains that they are confined to specific and narrow practical lines and are revived on "the spur of immediate practical advantage" (as in obtaining food), *i. e.*, they serve primarily as means to previsory adaptation.

The late appearance of 'representations' is again supported by Bethe's work on ants and bees (Pflüger's Archiv, LXX, p. 15). This author makes the mistake of assuming a memory image as a *sine qua non* for recognition. However, he finds no evidence of recognition of any sort in his insects, and even intimates that consciousness may be entirely lacking to all invertebrates.

These two monographs, and a few others of the same tenor,

[1] There seems to us to be some introspective evidence for this qualitative difference; this above the vast differences in intensive, spatial and temporal characteristics. Kuelpe, who has taken up the analysis of imagery where Fechner left it off, emphasizes the latter discrepancies and, though he holds to a qualitative likeness, admits that this is only an *apparent* likeness, *i. e.*, "a relation of contents in which they [centrally and peripherally excited sensations] evoke the same judgment." We are inclined to go further, and to say that the two when considered apart from the "judgments which they evoke" possess quite different qualitative systems. The fact that experience demands a superposition of the two systems explains their apparent likeness and also the occasional confusion of perception and memory. It is moreover conceivable that the different nervous elements, central and peripheral, involved in the two cases should occasion a qualitative difference in consciousness. [*Cf.* H. Ebbinghaus's distinction (*Grundzüge der Psych.*, I, 167) between *Empfindung* and *Vorstellung*. Unfortunately, we have so far (erster Halbband) only the author's bare classification of mental elements, and do not yet know the precise import of this distinction].

are infusing a healthy tone of scepticism into comparative psychology. They make the very recent appearance of the more complex processes—inference, 'reason,' free ideas, images of the memory—exceedingly probable.

Contact with surroundings, harmful and advantageous, must have called for early recognition, as we have indicated. Well-known stimuli would bring pleasure or pain, and hence would be courted or avoided;[1] new stimuli would be generally avoided. As the unexperienced had not been necessary for life, the organism could afford to shun the new. Thus cognition or simple recognition would govern reaction toward the immediate environment, and only a later and more complex stage would demand conscious prevision adaptation.[2] This stage would be the longer delayed because instinctive reactions are reinforced among some of the higher animals by a motor habit, set up through the individual's experience, which seems to mediate recognition without the addition of memory images. M. Bergson (*Rev. philos.*, XLI, 225 and 380) has laid stress on this

[1] The statement that the familiar is pleasant plainly needs limitation. The fact that the baneful as well as the useful recurs constantly in the individual's life is sufficient to guarantee that not all 'acquaintances' will be 'friends.'

[2] A genetic account of memory radically different from the one in the text is given by Professor J. M. Baldwin in *Mental Development in the Child and the Race*. Imageful memory is here accredited to most submammalian forms, but true recognition only to a very late period of development (pp. 319 f.). In the earlier, "simple memory" type are lacking "the finer motor, synthetic adjustments of the attention which by their variations constitute recognition." To us, the isolation of the image has seemed the difficult feat for consciousness, involving a nice control of the attention; while the 'familiarity' attaching to recognition was much the same for all such contents, and was easily provided for by a ready reception into the total consciousness and the peculiar motor reactions set into operation.

It is to be noted that the author has also called attention to the relation of the image to adaptation: he says (p. 319), "creatures which have in them the faculty of anticipating experiences, both pleasurable and painful, by the recall of memory pictures in something of the original setting, and which can, in consequence, anticipate the actual experiences to secure or avoid them by an adapted reaction, are most fit for natural selection." Our criticism of this position has been that the image, as simply a sensation aroused directly in the central organ, *may* assume one of several functions, anticipatory, memorial, imaginative or schematic. The storm and stress of existence point to this order as the natural one: anticipation, especially, seems the most elementary function of imagery, and not a mental product recast from the mould of pure memory.

Another explanation of the efficiency of memory images in aiding adaptation regards these as "idées forces," and demands that they be considered along with the physiological mechanics of memory. See Alf. Fouillée; "La survivance et la sélection des idées dans la mémoire;" *Rev. des deux mondes*, 1885, May-June, p. 359, and elsewhere.

type of motor memory, and gives as illustrations the dog's 'recognition' of his returned master, and with us the learning of a thing 'by heart.' This memory he sets over against imageful or 'pure' memory, whose rise he places at a later date. Whether or not an animal's definite and peculiar reaction to his master can justly be termed recognition in the usual sense, it seems much easier to err in ascribing it to the power of recollection *through images* than in limiting it to obvious motor concomitants *plus* strongly toned feelings. It seems, then, a useless abrogation of the law of parsimony to attribute to most of the lower forms of animal consciousness a power of abstraction sufficient to image the past or the future. If utility explains the existence of the image, as intimated above, one sees the close connection between memory and imagination. So long as a rough-and-ready attitude toward the world suffices for survival, images will not appear. It will only be after the non-present has been thrown up against the background of perception that its contents will be conceived as possibility, and then as warning,—and thence the way to prophetic adaptation is short.[1] Instinct aroused by 'familiar' stimuli comes to be superseded by conscious prevision. This prevision, though closely allied to imagination, is not to be confused with it. It is expectation, rather than imagination. In expectation, the image is set over against the present: in imagination, it drives out and supersedes it.

The acquirement of language, spoken and written, has made an essential change in the modes of memory. Visual and auditory images of things have been, through it, largely replaced by verbal memories. Written language, especially, has relieved imageful memory of a great burden. Traditions of the tribe handed down for generations are supplanted by histories: descriptive writings take the place of camp-fire narration. Language improves on images of the memory because it stereotypes. Among civilized peoples, old memory types persist but are of small value, in general. Indeed, few people are conscious of the memory type which they represent, although linguistic memory preserves the preference for visual, auditory or motor retention. The reduction of adaptation to a set of rules destroys largely the necessity for encasing the past in images kept for reference in preparing for future needs.

Still, the memory image has not entirely lost its function.

[1] An intermediate stage in this process is furnished by the memory after-image, which is immediately dependent on its peripheral excitation, and soon vanishes, but is a step toward the differentiation of the present from the non-present. For the time-limits of the memory after-image under distraction, see A. H. Daniels (*Amer. Journal of Psy.*, VI, p. 558).

Retention through the centers for vision, audition and movement often leads to imagery. Language, because of its fixity, requires to be supplemented by images which hold the concrete event for future use. Galton (*op. cit.*) makes some interesting observations on this point. He finds the visual imaging power very great in young children and in some wild races as, *e. g.*, the Bushmen and Eskimos, and remarks that "language and book-learning certainly tend to dull it," and that "our bookish and wordy education tends to repress this valuable gift of nature." He speaks of the French as facile visualizers and says: "the peculiar ability they show in prearranging ceremonials and fêtes of all kinds, and their undoubted genius for tactics and strategy, show that they are able to foresee effects with unusual clearness." He finds that "the faculty is undoubtedly useful in a high degree to inventive mechanicians, and the great majority whom I have questioned," he says, "have spoken of their powers as very considerable." And again: "a visual image is the most perfect form of mental representation whereever the shape, position and relations of objects in space, are concerned. It is of importance in every handicraft or profession where design is required. The best workmen are those who visualize the whole of what they propose to do before they take a tool in their hands." Galton does not distinguish sharply between the faithful memory image and the image of phantasy. His illustrations show how the former merges into the latter. Indeed he says (p. 173): "recollections need not be combined like mosaic work: they may be blended on the principle of composite portraiture. I suspect that the phantasmagoria may be in some part due to blended memories."

The whole realm of literature and fine arts, so far as it is the creation of phantasy, shows the memory image at sport; the phantasy stands to the reproductive image as play to work;[1] and, like these, the memory and phantasy images represent the activity of one and the same function. Memory, continually dropping and picking up its threads and dyeing them anew, weaves the bizarre fabric of the imagination. It takes its cue from utility, and here necessity truly is "the mother of invention." Compelled to utilize experience as a lesson for the future, the imaging tendency survives its most imperative need and loses itself in the vagaries of phantasy.

Briefly, then, our view concerning the lineage of the memory image is as follows. The earliest conscious reaction upon environment was provided by intimate connection of pleasurably-toned sensations with reactions appropriate for nutrition. Such

[1] Quite a different relation from the early prophetic and retrospective imageries.

reactions developed into complex instinctive actions in presence of both pleasurable and unpleasurable perceptions. Next, the distinction between the familiar and the strange (nascent recognition) appeared. As adaptation became too complicated and too delicate to be entrusted either to instinctive control or to response in face of critical stimulation, a discrimination between the present and the non-present arose with the appearance of general images. These images were excited in a variety of ways, and helped to govern action as peripheral stimulation—special and organic sensations—had done before. Special images set in a definite place in the 'future' and the 'past' came later, and mediated adjustment for special occasions. Simply as a part of the past the image has had little value, but as an index of the future its function has been important. With the rise of language, experience became conventionalized, and set rules replaced the less reliable images. These still persist, however, (1) where arrangements and previsions do not permit linguistic statement, and (2) as phantasy images.

CHAPTER III.

EXPERIMENTAL.

It is above all essential, in dealing with memorial imagery, to supply conditions which shall assure the presence of images. As we have before indicated, retention and even recognition do not themselves give such assurance except under certain definite conditions. It will be seen at once that there is a limited range of imagery from which to choose. Images of taste and smell are comparatively rare. Olfactory and gustatory memories usually reduce to peripherally 'reproduced' or to imaged puckers, smacks, swallowings, salivary excitations, inhalations, organic sensations, auxiliary ideas of space and time relations, and feelings. Smell and taste imagery proper is too scanty and too uncertain to turn to account in a preliminary study of imagery. There is an evident biological reason for the paucity of images from these two senses, in civilized man at least. Names, colors, general appearance, etc., have been of more service in the memory than direct images of taste and smell could have been. It is very probable, however, that in primitive conditions these had a much more important function. Haptical images, beside being vague and ill defined, offer peculiar difficulties. There is, in the first place, a strong liability of confusing images of the memory with sensations excited in the terminal organs. The sensory-motor connection is especially strong between muscular and tendinous images and

innervations. A concentration of attention on an imaged movement is pretty certain to become the adequate stimulus to peripherally initiated strain sensations. The difficulty of isolating 'muscular' images is shared by smells and more especially by tastes. Since the adequate stimuli to the last two senses are not definitely known, it often occurs that one is not sure whether one has a *bona fide* image or an actual excitation in the end organ. Of haptical images it may again be said that various factors—pressures, pains, temperatures, strains and joint-pulls—are so indissolubly interwoven that the isolation of any one sense image is well-nigh impossible. To this may be added the fact that skin sensations, because of their functional, external reference, are overgrown with visual associations.

Organic images elude so successfully the usual incentives to reproduction, and are so vague, as to put their employment out of the question.

There remain the two most highly developed special senses—audition and vision. Here we find a wide range of stimulus qualities and intensities, paralleled to some degree by a wealth of memorial imagery. Here, if anywhere, we ought to be able to isolate the image, to study its nature and function, and to determine its qualitative fidelity by close comparison with sensation.[1]

We have chosen visual imagery because it seemed to promise better material for moulding a satisfactory method, and because it delivered us from various technical difficulties which audition presents. We have not attempted much more than an exploration and scrutiny of methods, and a prolusion for subsequent work. We may be allowed to remark that a more systematic investigation than we have been able to make is now in progress in the department of acoustics in this laboratory.

The work with visual images extended over colors and brightnesses.[2] Brightnesses were found to offer the simplest conditions,[3] and were pressed farthest by various methods.

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[1] The inexact distinction 'sensation' and 'image' is employed simply as a matter of convenience. It avoids a long circumlocution, and sets off 'image' from memory in general. Kuelpe's distinction of "peripherally" and "centrally excited sensations" seems the clearest.

[2] Additional experiments on memory for visual form are not yet published.

[3] It hardly need be said that the reason for discussing only images of the various senses is their relative simplicity. Here one has the best opportunity for instituting a direct comparison between an image and its corresponding 'sensation.' As one retreats from sensuous 'reexcitations' one gets more and more on the border line between memory and imagination, and into the realm of general mental imagery, that is, into the region where the temporal position of the image be-

Methods. As we have seen, investigations of the memory suggest two principal methods: reproduction and recognition, and two auxiliary ones: comparison and description. Since our work was largely methodological, it seemed best to exploit as many different paths of procedure as possible.

(a) *Description.* The least accurate and the least used experimental method is the method of description. Objects, colors, forms, sounds and events usually admit of verbal description. The experience may either be retained in verbal motor images which are reported directly, or in any of a half-dozen other memories which are translated into descriptive terms for the report. A more primitive and direct mode of description, which lies in the direction of reproduction, is the gesticulatory and mimetic. Here a situation is associated with certain motor reactions, and these reactions when renewed serve to recall the situation to the narrator's audience. As we intimated above (p. 10), naming gives a clumsy classification of experience, inasmuch as the same noun or adjective may cover a variety of slightly different experiences which have not enough individual importance to attract separate names. In other words, the indirect is not adequate to the direct sensible discrimination. Külpe draws attention to this fact when he says that association by similarity may often be reduced to reproduction of a common name. As a case in point, Lehmann observes that the German language has only five common names for grays. This out of seven hundred brightness qualities. The case with tones is analogous. We may say, in general, that when small differences are to be looked for, oral description is impossible.

(b) *Recognition* we have seen to be a fruitful memory method. The caveat that was lodged against it in connection with the work of Lehmann and Wolfe has, however, made us cautious here. If 'reproduction' of an experience through an image is not the only modus for memory, the method of recognition is not likely to disclose the fact. The very fact that recognition and reproduction reveal such different capacities for retention points to the evident truth that the image is not the sole vehicle of memory.

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comes indistinct or altogether lost. The 'mental image,' if it is to be distinguished from images of memory, expectation, and imagination, is properly the image unplaced in time. Such an image is normally the result of many similar experiences; *e. g.*, my image of a pin is, until I develop it, a pin image and nothing more: (*cf.* J. Philippe, *Rev. philos.*, XXII, 2. Thus, much of experience gets its personal, episodal side worn off, and becomes 'common mental property.' Whether an image assumes the function of memory, expectation or imagination, or remains only a 'mental image,' depends, of course, largely on the context, and this is as rich and varied as mind itself.

(c) *Reproduction* by itself is limited in its range of application. In the first place, the reproduction (except in the case of muscular, including verbal motor, sensations) has always to come through another sense department than that to which the image belongs; *e. g.*, color, brightness and form through the hand and arm (mixing and drawing), tones through the throat. The reproduction of visual sensations has the further disadvantage that it takes time, and before completion direct recognition complicates the process. The same objection holds for the method of selection used by Baldwin and by Binet, though as a measure of memory capacity this method has value.

The foregoing criticism of the method of reproduction implies that the method covers indirect S. D. (report), as well as the immediate experience.[1] Taken in this way, it is at once seen how near the method comes to description. If, however, we mean by reproduction merely the unequivocal appearance of an image, we give the word a perfectly definite and legitimate signification. Taken thus, reproduction is quite indispensable to any work on images. It does not, however, give a complete method, and there still remains the task of getting at the image and recording it. This is the psychological problem which was stated in the beginning of the second chapter. The method is completed by a comparison of the image with some carefully chosen stimulus to which it is intimately related. It may be better to avoid entirely the ambiguous word reproduction in this connection, and to substitute the word 'recall,' to indicate that an image has been brought voluntarily into consciousness. The method by which it is educed and compared with a given sensation may then be termed the method of (d) *Recall and Comparison.* It differs from other methods (1) in scrutinizing the actual contents of memory, and (2) in making possible a direct comparison of image and sensation.

Apparatus. The Marbe adjustable color-mixer[2] was used. The mixer is run by an electric motor, and carries two intersecting discs of 11.5 cm. diameter. One of the two sectors is adjustable by means of a rack and pinion behind the disc, moving at right angles to it. The size of the adjustable sector is read off on a scale lying against the toothed rack. The ad-

[1] The distinction here between direct and indirect sensible discrimination might be brought out by the terms 'internal' and 'external reproduction,' or much better by reserving the word 'reproduction' for memory images: for mental processes which possess the function of direct reference to previous experience. The *expressing* of such experiences would then be 'productions,' as drawing, painting; or 'descriptions,' as talking, gesticulating: *i. e.*, either *direct* or *indirect* reports.

[2] For description of the apparatus v. *Centralb. für Physiol.*, VII, 811.

vantage of the arrangement is that one sector can be altered at will during rotation. In this way a continuous change of color is possible or, with a short interval for shifting, two successive stimuli can be given without introducing a space error.

Series I. The observer in our experiments sat before the disc at a distance of 2¼ meters. Exposure was made by lifting a black screen directly in front of the disc. In the first set of experiments the variable sector—60° to 100°—was White, and the other Blue, Red, Green or Black. The brightness or color stimulus r was exposed 5 sec., and after an interval—1 min. or 5 min. (in a few cases some days)—a second stimulus, either r_n (=r) or r_l or r_d, was given; r_l contained 5° more, and r_d 5° less of the white sector than r. We will call the first stimulus N, the second V. Just before the end of the memory interval the subject was asked whether he had a visual image of N. After V was exposed, the usual report, "same" or "different" (*i. e.*, "greater" or "less"), was passed. The object of the recall was to bring the image, if it persisted, into consciousness for comparison with V. Under the head of "images" the record was kept "good," "poor" or "lacking." "Good," as carefully explained to the observer, meant a definite visual image, clear and of a distinct quality, "poor" a vague, confused image, and "lacking" a failure of voluntary imageful recall of N. The experiments were performed in the daylight between 9 and 12 A. M., and a few between 3 and 4.30 P. M. Most of them were done with a clear sky; chance changes of illumination between any N and its V were sufficient cause for throwing out a record. The subjects were asked not to attend to N during the interval, and although no regulated distraction was afforded, introspective confessions indicate that it was not usually adverted to until the query as to the presence of an image was made. The subjects did not read or look at colors (except the very dull gray and buff tones of the room) during the memory interval. Their eyes, however, were kept open.

Four of my colleagues, Drs. Gamble (G) and Pillsbury (P) and Misses Dolson (D) and Burch (B)—all psychologists of some training—assisted as observers. A few results were also got with long intervals from five other students in the department (A., R., S., T., and Ti.).

In the year 1896-7, 600 results were obtained by this method; 500 with 1 min. intervals, 84 with 5 min. intervals, and the remainder with longer times.

In relating the arrangement of stimuli to the reports of the observers, three categories are possible, to wit: (1) objective and subjective agreement (C), *i. e.*, objectively equal stimuli are judged equal, greater greater and less less; (2) a memorial lightening (L), *i. e.*, a V=N is judged "darker," a V lighter

than N is judged "equal" or "darker;" and (3) a memorial darkening (D), *i. e.*, a V=N is judged "lighter," a V darker than N is judged "equal" or "lighter."

It will be seen that every deviation in judgment from stimulus magnitudes is a deviation of *at least* 5° of White. In some cases—as *e. g.*, equal judged darker or lighter—it may be much more. The results do not tell how much.

Table I shows the total results for the various subjects. Initials at the left indicate subjects; L, C, and D the categories above given; and the figures the number of experiments falling under each head.

TABLE I.

	L	C	D	SUM.
B	117	106	33	262
D	17	27	7	51
G	35	51	33	119
P	71	50	31	152
A. R. S. T. & TI.	11	4	1	16
Total Jdmts.	251	238	111	600

The most striking thing about the Table is the distribution of the L, C, and D cases. There are 13 more L than C cases, and more than twice as many L as D cases. Reducing the footings to per cents. we have:

L	C	D
41.9	39.7	18.4

Or, considering only the 'errors,' we find that 69.5% of these fall to the L side. This may be interpreted to mean that whatever stands in the memory for N has a tendency to change during the interval toward the light; *i. e.*, as compared with V, N becomes "too light" in the memory more often than it remains unchanged, and inclines to the light 2.3 times as often as it does to the dark.[1] Now, since a constant difference ($\Delta=5°$), which was found previously to be near the liminal value for our observers, was used, the results may be brought into a gen-

[1] An analogous case with tones—a rise in pitch through the memory—has been noted by Hirschberg (q. v.). Wolfe (*l. c.*, p. 556) holds that the reverse is true, *i. e.*, that a tone in memory is weakened and therefore lowered in pitch.

eral relation to those gained by the method of right and wrong cases.[1] With this method, if $\frac{r}{n} < 50\%$ there must be a constant error $> \Delta$. If we regard our C column footing (Table I) as giving the number of right cases $(\frac{r}{n})$, we find that its value is not only $< 50\%$, but that it is less than the footing of the L column (*i. e.*, $238 < 251$). We may therefore conclude that the constant error connected with the memory of N is considerably greater than the D used, namely 5°. More precisely what the value of the memory "error" is, the method does not, unfortunately, tell us. Even though the method were adequate, the number of cases is not sufficient for a strict interpretation by means of the probability curve.

It will be remarked that the judgments of *G* form an exception to the general tendency indicated by the Table. *G's* C–judgments are more frequent than the L or D ones, and these latter are approximately the same (35 and 33); *i. e.*, her errors are equally distributed in the two directions. Introspective notes made during the experiments, as well as results obtained later, furnish an explanation. *G* visualizes with great difficulty, but makes dexterous use of her verbal memories to cover the deficiency. If we add to this the fact that a large number of her reported images are general, that is, are 'mental' images instead of 'memory' images, we get a clue to the apparent anomaly of her results. Here is a case of what we spoke of earlier as the stereotyping effect of language. Verbal images when quite simple have little temptation to change, and when they do change it is not (except by accident) in a constant direction along a qualitative visual scale. *B* is a very facile visualizer and inclines but little to verbal or descriptive memory. *P* and *D* are fair visualizers and their verbal memories appear but little in the series. Of this we shall say more later.

Returning to the matter of the memory 'error,' we shall see that the tendency toward *L* judgments is also evident if the series is divided up according to stimuli used. See Table II.

The per cents. in the following Table must not, of course, be taken too seriously, since the whole series contains only 600 experiments. Still there is evidently a stronger tendency to lighten in the short-wave half of the spectrum (represented by Blue and Green) than at the Red end. Memory for Gray under these conditions seems to be only better than for Red.

The variable White sector alters, of course, the saturation as well as the illumination of the colors. That the change, due to the memorial factor, is, however, largely one of bright-

[1] The fact that Δ was sometimes omitted and N followed by V=N makes the procedure somewhat irregular. It will not, however, affect the general conclusion that we wish to draw.

TABLE II.

(W=60° to 100°.)

	L	L: SUM.	C	D	SUM.
Blue	90	48.4	68	28	186
Red	51	35.6	59	33	143
Green	45	44.1	29	28	102
Gray	65	38.4	82	22	169
Totals	251		238	111	600

ness is argued by the fact that the percentages under L fall so close together for the pure brightness values (grays) and the mixed values (colors). The exact amount of influence of the two factors could be determined only by a calculation of the brightness valences of the colors used. Spectral values would not apply to our papers; and, since the method does not give a maximal, but only a minimal value for the memorial alteration, the valences would be of little use. We will leave, then, the minor, saturation factor, and concern ourselves only with the bearing of memory on estimations of brightness.

Effect of Length of Memory Interval. Having found that the memory contents (we have still to ask what this includes) changes during the memory interval, we have now to inquire whether the change produced is a function of time elapsed. This inquiry, it is to be noted, differs from the inquiry of Ebbinghaus and others (*v.* Chapter I) into the available *amount* of memory material at any given time; that is to say, the relation of memory to obliviscence.

M. Philippe[1] (*Rev. philos.*, XXII, 5) concludes that "mental images" change in the following ways: (1) by fading, elements are dropped or confused; (2) to new images, but remain clear; and (3) toward a type.[2] This list of possibilities will serve our present purpose.[3] Leaving out the first

[1] The method used follows Binet, and involves the various disadvantages of description.

[2] F. Kennedy (*v. supra*) gives a similar list, *viz.*, fading, quantitative and qualitative change.

[3] J. H. Leuba found a similar thing with brightnesses (*Amer. Jour. of Psych.*, V, 370): dark and light images tend toward a medium value. Concerning his method it is to be remarked that (1) the existence of the image was not assured, (2) the standard stimulus was either always in sight or only called for at irregular intervals, (3) sensory after-

rubric, which presupposes a more complex contents than ours, we may ask if the qualitative change in the memory contents, whether toward a type or not, is a function of the time interval.

The following Table III gives the three classes of judgments by intervals elapsing between N and V.

TABLE III.

INT.	L		C		D		SUM.
1′	196	39.2%	205	41.0%	99	19.8%	500
5′	44	52.4%	29	34.5%	11	13.1%	84
2 days	5	62.5%	2	25.0%	1	12.5%	8
7 days	6	75.0%	2	25.0%	–	——	8
Total	251		238		111		600

The figures indicate that the tendency of the memory to lighten increases with the length of the interval. The results, however, demand further support.

Relation of Judments to Images Reported. As we stated earlier (p. 29), a record of images was kept along with the reports of likeness and difference, the subject attempting each time to bring to mind the proper image of N just before V was presented. The only exception to this was in the case of a few (17) early experiments with B.

The following Table gives the number of total experiments under each head, the number of 'good' images and the sum of 'good' + 'poor' images.

We may conclude from this showing: (1) that it is possible for some time afterward to recall a very simple visual impression by means of a visual image. In our series visual images of some kind were obtained in $\frac{5}{6}$ of all the experiments; (2) that after an interval of 5 minutes imageful recall is better—both for good and poor images—than after one of 1 minute.[1] The longer intervals are scarcely comparable with these be-

images were confessedly disturbing, and (4) the result just spoken of is probably to be referred to stimulation within the memory interval, since one image (if present) held over for several successive intensities. The indication of a general law for sense memory is extremely questionable.

[1] This is not in agreement with Lehmann (*Studien*, V, 153), who concluded that the visual memory image is of little value in recognition after one minute.

TABLE IV.

	L	Rel. of Ims. to Exps.	C	Rel. of Ims. to Exps.	D	Rel. of Ims. to Exps.	SUM.	Rel. of Ims. to Exps.
1′ INT.								
Exps.	196		205		99		500	
Good Ims.	121	61.7	118	57.5	51	51.5	290	58%
All Ims.	169	86.2	166	80.9	80	80.8	415	83%
5′ INT.								
Exps.	44		29		11		84	
Good Ims.	34	77.3	19	65.5	4	36.3	57	68%
All Ims.	37	84.1	26	89.6	8	72.7	71	84½%
2 & 7 DAYS.								
Exps.	11		4		1		16	
Good Ims.	4	36.3	4	100			8	50%
All Ims.	8	72.7	4	100	1	100	13	81%
TOTALS.								
Exps.	251		238		111		600	
Good Ims.	159	63.3	141	59.2	55	49.5	355	59%
All Ims.	214	85.2	196	82.3	89	80.2	499	83%

cause they were used by different observers, less trained and less reliable in their introspective reports. (3) It is to be noted, finally, that the largest percentage of L judgments is accompanied by images both good and poor, the C judgments next, and the D judgment next. That is, not only is there a tendency in the memory to lighten, but the tendency is strongest where the memory is a visual image. It is not, however, apparent that the change of the image is the sole cause for the lack of memorial fidelity. Our introspective evidence which is to follow will perhaps aid us here.

Series II. We observed in connection with the modified Right and Wrong Cases method that since Δ did not always appear it was impossible to calculate the exact amount of the memory error: then, too, the time consumed in the longer intervals makes it difficult to get a sufficient body of results for the application of the law of probability. For these reasons, the following new method was tried. A standard disc[1] (black and white) was presented to the subject 5 secs., and at the close

[1]Apparatus and papers (Zimmermann) used same as in former series.

of the memory interval (1, 2, 3 or 5 mins.) a variable disc 30° lighter or darker than the standard (N ± 30)[1] was presented, and shifted (made darker or lighter) until subjective equality was reached. As before, the attempt to produce a visual image was always made. Our observers were Drs. Gamble (*G*) and Sharp (*S*), Miss Carter (*C*) and Mr. Kairiyama (*K*). All were trained in psychological work.

The following Table gives the results. Set I was done during the fall of '97; Set II the following winter. The first column gives the observers, the second the degrees of white in the standards, and the following columns the degrees of white in the V's III N. The various values for V represent the average of four results.

TABLE V.

	Set I.						Set II.				
	N.	1′	2′	3′	5′		N.	1′	2′	3′	5′
K.	120	122.0	123.7	121.7	137.5	K.	120	124.5	122.2	123.0	118.6
	100	110.0	104.5	108.5	103.0		100	102.5	107.7	——	104.0
C.	120	121.5	123.2	124.5	113.2	C.	120	116.7	120.0	116.5	——
	100	97.2	97.2	102.7	100.2		100	107.0	103.0	97.0	——
G.	120	118.5	131.0	111.7	120.7	G.	120	120.7	122.7	120.0	122.2
	100	92.7	79.7	94.7	101.5		100	87.7	90.7	96.0	91.0
S.	120	118.5	116.5	119.5	125.7	S.	120	121.0	121.0	132.2	——
	100	102.5	101.0	104.0	103.5		100	98.2	103.0	100.0	——

The objective values for N were wholly unknown to the observers, who invariably supposed that several (5 to 8) values were being given. If they had detected that there were but two, their images would have become stereotyped after a few trials, and instead of reviving each time the immediately preceding sensation alone, the whole series would have contributed to the memory stock. This summation process is, in fact, impossible to be rid of entirely, however long the series of stimuli, and may as well be faced wherever qualitative memory work is attempted. In truth, it also appears in various psychophysical measurement methods; for example, in the methods of Average Error and Right and Wrong Cases, where the same stimuli are given over and over again. Two results follow. The first is indicated by Paneth (*sup.*, p. 4), who thinks that a thing may be remembered by its place in a series—by its relation to similar things—rather than in its own right. Now the more often a thing is experienced the more definite does its *locale* become. It is related just so and so to its neighbors. It is a gray (say) which stands in a certain relation to other lighter and darker

[1] The direction alternated.

grays. Even where, in other work, a long series of grays was used, there was a well-marked tendency in some subjects to put an impression immediately under a verbal rubric, or to retain the visual image by setting it directly into a line of grays.[1] The second result of this tendency is to complicate the memory process. The seventh term of a series in which a given stimulus is presented over and over again cannot be taken into the mental economy on just the same basis that the earlier terms are: the repetition itself has caused a bias. It seems to be just this kind of a bias which is at the bottom of various "time errors;" it has never been shown, so far as we know, that these are, or are not, connected with a memory image. It seems altogether probable that a stimulus affects the nervous system differently, even the first and second times, without any reference to an image.[2] This difference may then be simply emphasized, if the stimulus is given over and over again.

The method used in Series II is a compromise between reproduction and recognition. There is 'objective' reproduction—

[1] Cattell and Fullerton (*loc. cit.*, p. 149) make a similar observation.

[2] Kuelpe contends (p. 213) that the direction of the 'time error' with successive stimuli should be constant if the error is due to the weakness of the memory image: but it is not; sometimes the second stimulus seems greater and sometimes less. For example, Fullerton and Cattell found that the second of two successively lifted weights—interval 1 sec.—was over estimated (also Lehmann, Starke and Merkel), while with lights (same interval) the second was underestimated. With larger intervals only the probable and not the constant error is given. No satisfactory explanation is offered. A. J. Hamlin (*Am. Jour. of Psych.*, VIII, p. 53) found a tendency to over estimate the second stimulus when a memory image was present. Wolfe and v. Tschisch agree that tones weaken in memory. Leuba's results have already been noted. A. Wreschner (*Dritter Intern. Cong. für Psychol.*, p. 204, and *Methodol. Beitr. z. psychophys. Messungen*, 1898) calls attention to the memorial factor in the time error and says that (with weights) high intensities weaken in the memory, low intensities are strengthened, and a certain moderate intensity remains unchanged. He notes (*Beiträge*, p. 174) that *fading* of the image does not necessarily mean *diminishing:* a very important distinction. Like Leuba he finds a tendency for the image to approximate a medium intensity; this accounts for both the positive and the negative errors.

W's contention (p. 173) that memory plays different rôles in sensible discrimination (where the first sensation passes over almost immediately into the second), and in longer time-intervals, receives confirmation in our Series III, below, which indicates that different rules hold for short intervals—2″—6″—and for longer ones. We can, at least, say that the longer times afford greater range in memory materials. For the short times (S. D.), it does not seem to us that W. is entirely successful in substituting conscious memory (the image) for the physiological explanations of the time error offered by Fechner (*El. der Psychophysik*, II, p. 142) and by Müller and Schumann (*Pfl. Archiv.*, XLV, pp. 37 ff.). At the same time, he has contributed much toward a definite statement of the complex conditions under which this error appears.

production—inasmuch as the making of the stimulus is done under the subject's eyes. Instead of allowing him to mix his colors or grays, they are made for him. There is recognition, inasmuch as he pronounces on the identity of two impressions. It comes very near Baldwin's method of selection, too, since a series (unbroken in this case) is given and the subject selects the 'right' stimulus. It includes, not only a judgment of likeness, but also several judgments of difference.

For our use, the method has two points to commend it. (1) It shows the range of the memory 'error,' and (2) it gives a definite approach to a given stimulus from two opposite directions, thus improving on ordinary reproduction. On the other hand, its imperfections are not to be slurred. There is introduced, first, a source of error in the rate of change of the gray. The white sector was always adjusted by one person, the experimenter, who controlled his rate by means of metronome beats, thus minimizing constant and accidental errors of speed. A clock-work arrangement for adjusting the white sector was planned but could not be procured in time for use. The expectation error was eliminated and successive contrasts balanced by change of direction (N $\pm$ 30°). Expectation would, however, tend to obscure a constant memory error; *e. g.*, a change of +10° W. in the memory would require a movement of 30°+10° in one direction and 30°—10° in the other, while expectation would tend to reduce the difference. Finally, the employment of the memory image is rendered difficult by the presentation of a long series of V from which to choose. By the time the proper gray is reached, the imaged is obscured, though it was perfectly distinct at the close of the memory interval.

The large mean variation got from our limited number of experiments throws doubt upon the practical value of the method. This was as follows for all intervals:

K, 4.4°; *C*, 6.1°; *G*, 7.5°; *S*, 4.0°.

Thus the *m. v.* in the cases of *C* and *G* exceeds the minimal amount of memory increment (5°) found in Series I.

Individual Differences. Only in the case of *K* is there shown in Series II a constant and decided lightening in the memory. The result is noteworthy. A gray of 120° W. is judged to be equal (after the intervals 1′, 2′, 3′ and 5′) to 123.2°, 123.0°, 122.4° and 128.0° and a gray of 100° W. to 106.2°, 106.1°, 108.5° and 103.5° respectively. This, in face of the levelling tendency of expectation, means a very positive tendency of the memory. It has already been remarked that *G* avoids visual memories. Introspective notes, accompanying the results here considered, confirm this. The grays were often held in memory by a verbal associate: *e. g.*, the observer found herself using the

terms "very dark," "medium dark," "medium," etc. These were used as genera, and several grays lying near together could be brought under each by further verbal qualification. Where an image was present in its own right before the second stimulus came, it was referred to verbal descriptions to test its validity and was judged 'right' or 'wrong.' The observer's capacity for visual images seemed entirely inadequate for the work in hand. These facts afford an explanation for *G's* large *m. v.* and for the lack of constancy in the direction of her errors. The distribution of her errors is very much the same as it is in Series I (*cf.* Table 1). Her scheme of names is undoubtedly responsible for the general underestimation of the 100° stimulus (Table V). *G* failed to discover traces of mood[1] in recognition of grays as 'like' or 'different.' There was, at times, a perception of strain, little localized, and of oppression and heat about the chest, when trying to recall, but these phenomena were rather connected with the attention than with recognition or reproduction itself. Finally: an unusual variation in the stimulus, as a purplish or yellowish hue, was emphasized and exaggerated during the interval, doubtless by verbal description.

C is slightly more visual than *G*, but her visual memory does not stand by itself. She reported her images to be patches of gray indefinite in outline. These were placed in front, to her left, or in the back of the head. Images were got by an effort: recollection was accompanied by strains in the back and chest. The strains worked upward and ended in the scalp. Diffused sensations from the trunk were prominent. If the effort produced an image, it was either accepted, or rejected as wrong. Like *G*, the observer used other criteria than visual images for her authoritative memory data. For *G's* verbal memory, *C* substituted freely organic sensations and feelings. She stated that gray cloths had interested her greatly on account of the strong affective tones which they produced. Light grays were extremely pleasant, dark grays unpleasant, some of them even ugly, and medium grays indifferent. The same feelings were produced by the gray discs, though repetition reduced them very much.[2] In the last half of Series II, *C* had seven general rubrics which corresponded to cloths. These 'generic' images it

[1] The circumstances were unfavorable for a "recognitory mood." Our experience is that this appears in complex, visual and aural situations, with a strong practical interest attaching. Smells and tastes, though comparatively simple, are generally rich in affection and are not, for that reason, lacking in mood. Experiment, on the other hand, deadens intrinsic interest and rapidly lessens mood.

[2] Light grays were recalled easiest, dark next, and medium with greatest difficulty. Thus is shown a direct relation between feeling *and capacity* for reproduction.

was which came up for approval with the effort. They do not depend on verbal associations so much as *G's* images do, but are permanent visual furniture, supported by a mass of associated situations (people met, *e. g.*) and affective coloring.

If we reckon qualitative fidelity of the memory in inverse ratio to the amount of deviation from the memory stimulus = N, we get for *C* and *G*, F_c: $F_g = 2:1$, *F* standing for fidelity and the figures for the two deviations—6° for *G*, and 3.15° for *C*. It does not need to be added that this is a measure of general functional memory, and not of the visual image. Even as indicating capacity, it would be a doubtful exponent of these memory types, in general, since individuals show such amazing variety in the combination of memories.

S has a more useful visual memory than *C* or *G*, but relies a good deal on verbal descriptions and other secondary criteria: *i. e.*, visual associations. There was detected no trace of mood in connection with her judgments and no organic or general adjuvants. The average deviation of the second from the memory stimulus is 2.92°. The Table (II) shows a slight tendency toward the light.

Leaving the general results, let us select those in which "good images" were reported. These stand in Table VI. K is not included, since practically all of his results fall within the above category (*v. sup.*).

TABLE VI.

SUBJECT.	NO. EXPS.	N	V
C	3	100	109.0
	3	120	129.0
G	8	100	97.7
	9	120	132.0
S	12	100	101.0
	14	120	123.0

The Table explains itself. *G's* one exception is readily understood by what has already been said. Her best images, even, were not much relied upon by herself. There is, however, quite a difference between the 97.7° and the corresponding values in the general Table (V).

There is in connection with Series I and II one further point which seems to us important.

It frequently occurred, with all the observers of both series, that a judgment was given with no hint of a comparison of two stimuli. Even where no active recollection was possible, no

vestige of an image surviving the interval, a decision came like a flash with the giving of the second stimulus.

By much questioning we found that the observer's confidence in the correctness of his decision was quite strong in such cases, but usually he was entirely at sea when asked how he made the judgment. There was no trace of a comparison, no trace of the coupling of sense with memory contents. The expression of sameness or difference seemed on the tongue in the instant, without the vaguest allusion to anything past or absent. Such are the short-cuts of memory! An orderly, logical sequence which one thinks one *ought* to find turns up missing. And it is not to be wondered at: experience has crowded meaning into shorthand strokes of consciousness. The result is hard to decipher. Here, processes are ground together into a matrix: there, processes are dropped out entirely; the product glows with functional aptness, but the original elements are nowhere to be discovered.

It seems as untrue to assert that when I meet my friend, I necessarily compare him with a memory image of him, and pronounce the two the same before I extend my hand, as to affirm that the chicken ratiocinates before he proceeds to devour his worm.

Just what occurs in the apparently simple cases which we have cited, we cannot always say. The work *seems* to have all been done for consciousness, and it has only to believe and to report, to be credulous and to gossip. A certain stimulus, if preceded by a certain other, *sets* the organism in a particular way. It is a refined case of the dog's 'recognition' of his master. We simply react appropriately to the stimulus. Undoubtedly, affections and moods often contribute to meaning, but in such schematic cases as we have referred to, these, even, are often lacking, and we can scarcely find anything left to explain and vindicate a judgment.

Series III. The observation that a cloud passing across the sun in the interval seemed to affect the 'memory error' suggested the possibility that the character of visual stimulation during the memory interval might influence the fidelity of the memory.[1] If this be true, we concluded that it ought to be most marked in our work with those subjects who are preeminently visual. That is, a *visual* memory should be altered by continuous *visual* stimulation, whereas a motor or other memory should not be so altered. To test this, observers were blindfolded during the interval. It was, however, observed at once that this would not do, since the conditions

[1] We have since found the same suggestion made by Dr. Hamlin (*op. cit.*, p. 58).

under which the two successive stimuli were given were not identical. The first stimulus followed daylight, while the second followed darkness. Successive contrast was sure to interfere. To eliminate this difficulty, the observers received stimulation from the window of a dark chamber placed within a larger dark room. As the eyes were entirely cut off from external stimulation before either gray was presented, the conditions courted were obtained.

The arrangement was as follows: the adjustable color-mixer described above was placed behind a black screen having a circular opening cut in its center just large enough to let through the face of the disc. In front of the screen and at angles of 45° with the plane of the disc sat two reflector boxes holding kerosene lamps. The position of the lamps and the boxes was always the same, and the height of the lamp flame was kept constant by measurement. The dark box enclosing the observer faced the screen. The observer placed his head in a wooden mask (2 meters from eyes to screen), adjustable vertically, and at a signal pulled open two sliding doors set on the cylindrical front of the mask. The doors when open exposed the disc to both eyes. They closed in front of the nose by means of an elastic band and moved outward and backward in opening. They were supplied with cords and pulleys to be operated by the experimenter, but it was found to be more convenient for the observer to operate them. The mask served also as a head-rest, this insuring steady gaze and a constant position.

A warning signal was given 2 seconds before the doors were opened. Each exposure lasted 2 seconds.[1] The light intensity used gave at times very faint after-images for about 5 secs., and occasionally for 10 secs., but these were so weak as to be unnoticed except in a very few recorded cases. Eleven intervals between 2 and 60 secs. were used (Table VII). The short times were taken, to indicate more precisely the influence of time on the qualitative fidelity of the image. Instead of producing the image at the close of the interval, the subjects were asked to make every effort to hold it throughout the interval. When an image disappeared, the subject reported "gone," and when it reappeared, "now." These reports and their times of occurrence were recorded for 1,100 experiments—25 for each interval with each of the four observers (*cf.* Series II).

The stimuli used were grays of 60° and 70° white. This difference, like the one in Series I, was about liminal. Other

[1] Other times were tried but were less satisfactory for short intervals. The dependency of the memory image on the duration of the stimulus ought to be investigated.

intensities were given at times, and the observers were always ignorant of the exact number of stimuli used. All agreed that several were given them.

There were four possible orders for presentation: ab (60°–70°), ba, aa and bb; and three possible judgments: "same," "lighter" and "darker." Five trials were carried through all the intervals for each observer in this order: 2″, 60″, 4″, 50″, 6″, 40″, 10″, 30″, 15″, 25″, 20″; then five of a new pattern with this order reversed, *i. e.*, 20″, 25″, 15″, etc. This succession was chosen to distribute the effects of practice and fatigue. Each sitting occupied fifty minutes in the forenoon, usually at nine or ten o'clock.

The results follow: the figures at the top give the intervals and the letters at the left are those used in the earlier Tables. The zero line shows failures to judge, *i. e.*, obliviscence.

TABLE VII.

	2″	4″	6″	10″	15″	20″	25″	30″	40″	50″	60″	TOTALS.
D	19	20	18	28	31	26	26	23	28	29	28	276
C	60	62	65	62	59	59	58	59	60	53	58	655
L	20	17	14	7	7	11	12	13	8	12	10	131
o	1	1	3	3	3	4	4	5	4	6	4	38
	100	100	100	100	100	100	100	100	100	100	100	1100

If it be true that visual stimulation alters in a definite way the central residues of visual sensations, we should expect that a "dark" interval would pull the memory residue toward the dark, whereas a "light" interval would tend to pull the memory residue toward the light.

If we set our totals for Tables I and VII side by side we have the following:

TABLE VIII.

	L	C	D	SUM.
Table I (light Int.)	251	238	111	600
Table VII (dark Int.)	131	655	276	1100
Table I: % of Errors.	69.5	—	30.5	100
Table VII: " " "	32.0	—	68.0	100

That is to say, in the *light*, 69.5% of all errors made show a *lightening* in the memory; in the *dark*, 68% show a *darkening*

in the memory. This confirms our hypothesis that a "stimulated interval" has an effect upon the visual memory.

Concerning the effect of length of interval upon retention we find, in general, (1) that the C values show a slight decrease in the longer intervals; (2) that the D values show a corresponding increase; and (3) that the L values decrease more rapidly than the C values. We notice, therefore, that the memory loses slightly in accuracy as the interval increases from 2″ to 60″, and that the tendency of the memory to darken becomes more pronounced.[1] For the intervals 2″, 4″ and 6″ the number of D and L cases is practically the same. The accuracy of the memory is greater in this series than in Series I and II. Here, only 38.4% of all judgments are error judgments; in Series I, 60.3%; only a rough comparison can be made with Series II. The difference in accuracy is probably partly due to the length of interval, but doubtless the difference in general conditions and the Δ used have something to say.

Images and Individual Differences. The habitual memory modes of our various observers have already been discussed under Series I and II. We found that *K* was strongly visual, *S* less so, while *C* and *G* used visual imagery with difficulty, *G* relying mainly on verbal associates and *C* on organic sensations and feelings. Constant introspective reports during Series III confirm the accuracy of this evaluation. With the emphasis now on the image (reported through the interval) *K* depended entirely on visual residua; *S* more than before; *G's* visual memory was slightly aided; while *C's* habitual modes seem to alter scarcely at all; in fact, these seemed at times to be accentuated.

The distribution of their judgments stands as follows:

TABLE IX.

SUBJECT.	L	C	D	0	SUM.
K	16	173	85	1	275
C	34	191	32	18	275
G	41	152	67	15	275
S	40	139	92	4	275
	131	655	276	38	1100

Each observer showed various fluctuations in the number of

[1] We find nothing to corroborate the periodicity of memory noted by Dr. Wolfe and others. The reappearance and disappearance of the image through the interval seems to be partly a matter of visualizing capacity and partly a matter of attention.

D judgments at different intervals, but these seem to be without special significance (v. p. 43, note).

G had a memory after-image 259 times out of the 275; this began immediately after the first stimulus went, and gradually faded away.[1] In the 8 intervals, 10″—60″, the time of the image was nearly constant. The average duration was 5.8″ with an *m. v.* for the various intervals of only .5.[2] According to the subject's iterations, the images constantly grew darker. Since a true visual memory image rarely came to *G* after the disappearance of the memory after-image, we conclude that the darkening apparent in the results is due to the scanty visual factor, the memory after-image, which the observer was able to command by her best effort.

C's retention in this series was evidently in terms other than visual. The verbal element, as before, played a part and was assisted by the strong feeling tone and organic sensations. The observer herself considered the intensity of certain strain sensations to have adopted the function of memorial retention. The retention times that she reported are evidently due to this, and are not indicative of real visual memory after-images. They stand as follows for the various intervals: 2″, 4″, 6″, 9.2″, 13,″ 14″, 20.4″, 23.2″, 27.5″, 30″, and 31.8″. Occasionally a second "reproduction" was reported in the interval, but this lasted a very few seconds and vanished. Cases of immediate judgment without conscious comparison were exceedingly frequent with this observer. These, we conclude, are to be explained by the psychophysical "set" of the organism, which did duty for a more conventional memory contents. The juxtaposition of this memory representation and the second stimulus was the immediate incentive to the reproduction of the word "same" or "lighter" or "darker" without the emergence in consciousness of a comparison. One cannot emphasize too strongly the tendency of the organism to cut corners, and to avoid logical categories whenever they are superfluous.

K calls for little comment. His visual image was nearly always at hand when the second stimulus was presented. *S* gained somewhat in her visual mechanism; while she was not so typical as *K* she was decidedly visual in her memory. The interference by visual (stereotyped) associates will probably account for the smaller number of her D judgments.

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[1] The difference between sense and memory after-images was insisted upon, and fully understood by the observer. Fechner's distinctions were kept in mind.

[2] Fullerton and Cattell (*Perc. of Small Diff'ces*, p. 149) observe that the memory image with lights seems to last 9 secs. Probably this is the memory after-image proper. A. H. Daniels thinks that the memory after-image lasts less than 15 secs. if the attention is withdrawn.

Subsidiary Methods. I. Recall and Selection. A number—3 or 5—of slightly different colors (papers) were exposed successively by a Jastrow drop apparatus. At the close of the interval (5 or 10 minutes), the observer was asked if he remembered one of the colors (say the second in the series). If he did, a longer series (10 or 12) was presented as before, and he reported when the remembered color appeared. When approximately the same brightness was used throughout the series, no constant direction of change was observable: when, however, a series of brightnesses, *i. e.*, 14 reds, greens or violets running from light to dark, was given to select from, 58 correct selections, 17 too-light, and 6 too-dark were made.

"Here again, then, with the light-adapted eye (daylight), the memory grows lighter."

II. Burette Method. The subject looked toward the light through an aqueous solution of a pigment contained in a thin glass jar (width 15 mm., height and length 65 mm.). After an interval, the condition of the image was ascertained and then a weaker or a stronger solution was shown and altered by burette droppings until the subject pronounced the color to be the same as that represented by the image. The color was faded by simply adding water from the burette, and deepened by adding a saturated solution of the pigment. The value of the solution was always known in terms of volume of water and weight of the color-stuff. A screen hid from the observer everything but the solution, which was continually stirred by a glass rod.

III. Direct Production. A color was spread as evenly as possible on heavy white paper, and after an interval (1 or 5 mins.) the observer was allowed (using the same materials) to reproduce the color. The errors due to the method were found to be much larger than the proper 'memory error.' In about half the cases the produced color was lighter and in the other half darker than the memory stimulus. (The two were equated by making them into discs and adding a white sector to one or the other.) The method may be of use where very long memory intervals are involved.

None of these secondary methods proved to be entirely satisfactory, though each promised some tempting advantage. It seemed particularly important at the outset to try direct 'production' and 'reproduction' methods since these appeared to offer the best conditions for the isolation of the image. But after our previous criticism of methods, the partial failure of these auxiliary ones may be explained. We have found, in connection with these, (1) that it is impossible to get a well-graded series in paper colors (outside the discs), (2) that successive contrast must be avoided, (3) that solutions tend to be not

uniform, and introduce too large errors for qualitative memory work, (4) that it is difficult to spread an even surface of color, and (5) that the time and conditions required for 'production' introduce special errors.

We suggest as more ideal stimuli than we have ourselves employed: (1) for colors, a spectrum with a movable narrow slit, and (2) for brightnesses, a constant lamp in a sliding plane with a photometric screen for the projection of rays.[1] These suggestions are made because we have found the examination of qualitative fidelity of simple contents to require more refined and discriminating methods than we at first thought necessary. That is to say, for short times, the amount of change in a constant direction of the memory image is quite small, and can be isolated only by great care and under the most favorable conditions.

CONCLUSION.

After an examination of the memory literature, we have to say that investigations have been, for the most part, directed to memory as the capacity for retention, and to the various factors which condition retention. Reproduction and recognition have been used uncritically and their real basis has often been misconceived. 'Reproduction' not infrequently results from the combination of peripherally excited sensations —special and organic—with a recollected memory core, or simply a word, which may be quite different from the original experience in point of contents. As Professor Kuelpe expresses it (*op. cit.*, p. 190): "Der eigentlich psychologische Vorgang kann daher bei der Erinnerung und bei der Phantasie sehr mannigfaltiger Natur sein, d. h., die Bewusstseinsinhalte, welche als Erinnerungsmotiv gelten oder als Phantasien aufgefasst werden, können ebensowohl ganz verschieden sein, wie die besonderen Urtheile, die ihnen eine solche Bedeutung beilegen." Simple recognition stands much nearer positive or negative identification (expressed by affirmative or negative judgments) than it does to pure memory, and the alleged act of comparison with a memory image is rather a logical formulation, suggested by the judgments 'like' and 'different,' than a psychological statement of fact.

A static as well as a genetic view of mind brings us to the conclusion that the image is a late development, and that its primary function was to prepare the organism for future adjustments. From this standpoint are explicable the partial passage of memory into phantasy, and the weakening of memory fidelity.

[1] *Cf.* Fullerton and Cattell, *op. cit.*, p. 135, and Hess and Pretori, *Archiv für Ophthalmologie*, XL, 4, pp. 1 ff.

The experiments carried on for the special investigation of the visual memory image and its fidelity to an original presentation lead us to the following conclusions.

I. Even as simple a stimulus as a colored or gray disc permits a noteworthy latitude in modes of memory which individual psychology would do well to consider. (1) An observer who is pre-eminently visual may image the color or brightness directly. (2) Names, or verbal descriptions or associates, are not, however, entirely excluded, and become of primary importance where the verbal type of memory is strong and the visual deficient. (3) There is marked evidence of the influence of feeling on memory, wherever the affective reaction of the individual varies within a series. And finally, (4) strain sensations about the head and in the trunk, with, perhaps, general bodily sensations, seem to facilitate retention and recognition in certain cases.

II. Discs—grays and colors—shown and remembered in daylight tend to grow light in the visual memory. This fact was supported by all of our observers but one, who is very deficient in visual images, and confessed that names and verbal associations mediated her memory for the discs.

III. Discs—grays—shown in a dark chamber display a tendency in the visual image to grow dark during an unilluminated interval. No lightening is observed with unilluminated interval.

IV. These last two points (II and III) persuade us that the condition of the retina in respect to stimulation during the memory interval is important for the memory image. Illuminated and unilluminated intervals, where all other conditions are constant, are followed by different judgments with the same memory stimuli. We conclude, therefore, that in all experiments with brightness and color, where a time interval is involved, care should be taken to control the state of the visual organ. It is not improbable that a similar caution would apply to other sense memories. This obvious influence of the periphery upon memory indicates the close connection (perhaps the identification) of the sense and memory centers, in the cortex.[1] It also shows that the memory is not to be regarded as a storehouse of perfectly conserved images, but that the most simple memories are continually exposed to change, and that it is, at times, only

[1] Against this noteworthy influence of sensation upon image we have the indication (*v.* note above, p. 21) of a qualitative difference between the two. These two things do not, at first sight, seem to find explanation in the current theories of central localization. It seems wise, at this juncture, to suspend judgment on the various theories—even Flechsig's separate-centers theory—and to wait for more decisive evidence.